Regional HOT Lanes Network Feasibility Study

Task 3 – INITIAL ASSESSMENT REPORT

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1.1 INTRODUCTION

The Metropolitan Transportation Commission (MTC) is examining the potential of building on the existing and planned high-occupancy vehicle (HOV) system to create a regional network of high-occupancy toll (HOT) lanes. This could be done by converting existing HOV lanes to HOT lanes and expanding the HOV/HOT system where possible. Potential benefits include more efficient use of freeway capacity and a more reliable and faster travel option for carpoolers, express bus riders and toll payers. HOT lane revenues would be used to fund operation of the HOT lanes and may, in some cases, help fund express bus operations or expedite capital improvements including expansion of the HOV/HOT network.

This study recognizes previous work performed by the Alameda County Congestion Management Agency (ACCMA) and the Santa Clara Valley Transportation Authority (VTA) on HOT lane planning as well as work of the California Department of Transportation (Caltrans) on HOV lane planning. Specifically, this study builds on ongoing analysis for the I-680 Smart Carpool Lane over the Sunol Grade and the 2005 Santa Clara County HOT Lane Feasibility Study by VTA.

This working paper presents an initial assessment of the travel impacts, costs and revenues associated with a regional network of HOT lanes. Background technical data for this analysis is presented in Appendices A through F of this document.

1.2 REGULATORY SETTING

New federal and state legislation would be required for implementation of the Bay Area HOT lanes network. The following outlines existing federal and state laws that pertain to HOT lanes.

Federal Law

ISTEA specifically authorized the creation of up to five congestion pricing pilot programs, no more than three of which could implement tolls on the interstate system. The program, renamed the Value Pricing Program in TEA-21, has been continued through successive reauthorizations including SAFETEA-LU and has provided funding for the planning and development of several HOT lanes projects. The objective of this program is to encourage implementation and evaluation of value pricing pilot projects in order to promote economic efficiency in the use of highways and support congestion reduction, air quality, energy conservation, and transit productivity goals. SAFETEA-LU maintains a limit of 15 pilot pricing programs.[1]

In contrast to prior legislation, SAFETEA-LU grants states broad authority to implement HOT lanes on interstate and non-interstate facilities. Section 1121 of SAFETEA-LU replaces Section 102(a) of Title 23 of the United States Code (23 U.S.C.) with a new Section 166. The new legislation allows states to charge tolls to vehicles that do not meet the established occupancy requirements to use an HOV lane, provided the agency meets certain criteria to enroll participants, collect fees electronically, manage demand by varying tolls, and enforce against violations. SAFETEA-LU establishes minimum operating standards for HOT lanes. There is no limit on the number of projects or the number of states that can participate.[2]

1.2.1 California Law

State law remains more restrictive than federal law. State law, amended by 2004 legislation (AB 2032, Dutra), permits implementation of new HOT lanes as demonstration projects in a few specific cases: two new HOT lane projects in Santa Clara County, two in San Diego County, and the I-680 Sunol Grade HOT lane and one additional project in Alameda County. AB 2032 sets forth specific requirements for each of the demonstration projects including:

[1] See http://ops.fhwa.dot.gov/tolling_pricing/value_pricing/index.htmfor additional information.

[2] See http://www.ops.fhwa.dot.gov/tolling_pricing/programs/hov_facilities.htm for additional information.

1. A minimum level of service C must be maintained in the HOT lane (this may be relaxed to level of service D through consultation with Caltrans);
2. Revenues from each HOT lane must be spent on investments within that corridor;
3. An evaluation must be conducted for each project and submitted to the legislature.

In May 2006, the governor approved AB 1467 (Nunez), which increases the number of HOT lanes projects by four (two in northern California and two in southern California).[3] These projects must be reviewed by the California Transportation Commission (CTC) and then approved by the legislature prior to implementation. The requirements established by AB 2032 also apply to the projects authorized under AB 1467.

1.3 STUDY APPROACH AND ASSUMPTIONS

Two potential HOT lane networks are considered in this initial assessment. The "Existing and Funded Network" consists of converted HOV lanes expected to be in operation by 2015. The "Connected Network" consists of the Existing and Funded Network plus additional HOT lane segments that could potentially be in place by 2030 to close gaps and extend the regional network. Many, but not all, of the additional HOT segments in the Connected Network are identified for HOV widenings in the financially constrained portion of the regional long range plan, *Transportation 2030*, or in the 2002 HOV Master Plan.

1.3.1 Cost Estimating Assumptions

HOT lane costs are estimated based on previous work conducted by Caltrans, ACCMA, and VTA as well as commonly accepted unit costs. All cost figures are in 2006 dollars. Design assumptions influencing the capital cost estimates are listed below. (See the Task 4 paper for this study for a more detailed discussion of HOT lane design features and tolling equipment.)

- HOT lanes would be separated from the adjacent general purpose lanes by painted double yellow lines and four-foot buffer.
- Where right-of-way permits, HOT lanes would be a standard 12-foot lane width and existing lanes would not be narrowed to accommodate the HOT lane.
- Widening may be needed in spot locations to accommodate electronic toll pricing gantries, CHP enforcement areas and weaving lanes at ingress and egress locations; these costs are captured in the contingency for this initial assessment.
- The average distance between ingress locations, and, thus, toll tag readers and variable message signs would be four miles. Readers would be located immediately downstream of each entrance on same sign pedestal as a variable message sign posting the price and travel time in the opposite direction, thus there are two such installations in each direction for access openings in each direction. At each ingress location there is one variable message sign installation advertising the price and travel time and two redundant readers and enforcement cameras.
- Communication along the freeway is not assumed to be shared with any existing fiber telecommunications ITS infrastructure that may already exist. This assumption will be revisited when more corridor detail is developed.

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[3] See http://www.dot.ca.gov/hq/innovfinance/Public_Private%20Partnerships/ab_1467_bill_20060519_chaptered.pdf#search=%22california%20AB%201467%22

1.3.2 HOT Lane Demand and Revenue Forecasting Approach and Assumptions

The MTC travel forecasting model is used to forecast future travel and a separate toll optimization model is used to estimate HOT lane utilization, toll levels and revenue.

The revenue and other performance statistics presented in this report depend upon numerous policy and modeling assumptions. Most important among these are the following:

- It is assumed the tolling policy has the primary objective of maximizing the value of travel time savings across all of the users of a facility, subject to the overarching constraint that a minimum LOS be maintained. The objective maximizes travel time savings for HOVs, toll paying vehicles, and vehicles in the general purpose lanes. The assumed LOS constraint is that vehicle per hour (VPH) in the HOT lane will not exceed 1,600, which is roughly equivalent to LOS C. (See Section 1.4.)
- It is assumed that the facility will be operated and priced seven days a week, twenty-four hours per day. This assumption is particularly influential on revenues in future years when peaks are broader and midday volumes higher.
- Operational constraints on HOT lane access have not been modeled explicitly. Management of merge-weave turbulence, toll compliance and system cost and other considerations likely will require limited access and/or egress as part of the engineering design. The unlimited access assumption made in the modeling for this initial assessment simplifies these issues. Depending upon the natural pattern of access and egress in specific corridors, abstracting from these considerations may have little import or may overstate somewhat the revenue potential of a corridor.
- The toll treatment of HOVs has a major influence on the performance of HOT lanes. The modeling examines two policy alternatives in each corridor. The first, called “2+ HOV occupancy requirement” in shorthand, assumes vehicles with two or more persons may use the HOT lane free of charge. The second, called “3+ HOV occupancy requirement” assumes a carpool must have at least 3 persons to use the HOT lane free of charge. While this study examines the revenue and traffic impacts of both policies in each corridor for illustrative purposes, the assumption is that the HOV 3+ policy would be applied only in those corridors where it is in place today or where carpool volumes under an HOV 2+ policy would begin to approach the level of service C threshold.
- The modeling for this initial assessment does not reflect feedback from the tolling model to the regional travel demand model. This simplification reduces the analytical effort required by several orders of magnitude. It likely does not affect the relative performance observed across corridors or road segments. In order to obtain better measures of absolute performance, however, feedback of tolling to the regional travel demand model is required and will be conducted in future phases of work.

The forecasting performed in this initial assessment models explicitly the variation in conditions across 400 road segments, two carpool policies, two time periods and two HOT lane network configurations. In addition to these explicitly modeled conditions, there are other factors that will influence HOT lane network potential. Other variations were subject to sensitivity analysis rather than comprehensive modeling. Sensitivity analysis examined the effects of hybrid vehicles use of the HOT lane, the effect of alternative toll management objectives, and rough estimates of the effects of model feedback.

Hybrid vehicles in California may obtain stickers permitting SOV hybrid vehicles to use HOV lanes and exempting hybrids from tolls on HOT lanes. Under current law, the total number of hybrid HOV lane permits is capped. Should hybrid or other low-emission vehicle usage grow, hybrids will reduce the available HOT lane buy-in capacity. The exact impact on the operations and revenues of HOT lanes depends upon the specific local conditions. However, even at current levels of use, hybrids may reduce revenues by as much as forty percent (40%) in some corridors. Carpool and hybrid pricing policy clearly will have to be coordinated with the goals of HOT lane policy objectives.

Alternative toll management objectives influence the traffic and revenue performance characteristics of HOT lanes. For example, using tolls only to assure maintenance of a minimum LOS constraint is an objective that is used on two other US HOT lane facilities (one in Minneapolis and one in San Diego). This objective generates less revenue and lower savings in the value of travel time than the selected objective. Similarly, the tolls could be managed solely to maximize the revenue potential of the facility. In this case, revenues would exceed those likely to be generated under the selected policy but user benefits, in the form of value of travel time savings, likely would not be fully optimized. The choice of toll management objective will depend upon the relative need for revenue and user benefits.

1.4 HOT LANE CAPACITY

For planning purposes, HOT lane "capacity" can be defined by a maximum allowable number of vehicles per hour. Once a policy capacity level is selected, tolls are set in such a way to keep the HOT lane traffic at or below that level.

A number of studies have assumed the need to preserve a LOS C or better condition on the HOT lanes to ensure that the user is gaining travel and reliability benefits or, in some cases, to meet legislative requirements such as that in California law. According to the Highway Capacity Manual, vehicle volumes reflecting LOS C may vary based on roadway design, operational conditions, traffic composition and other environmental factors. Operational and performance experience from concurrent HOV lanes (one lane in each direction with little or no median shoulders or buffer areas) suggests that speeds and operational reliability start to fail in various conditions when volumes exceed 1,550 to 1,650 vehicles per hour (vph) per lane.

Previous HOT lane studies in the San Francisco Bay Area (in Alameda and Santa Clara counties) have assumed maximum allowable volumes in the range of 1,450 to 1,650 vehicles[4] per lane per hour. Operational analyses of HOT lanes on the I-680 corridor in Alameda County have assumed a maximum of 1,600 vph because the most heavily used Bay Area HOV lanes presently operate at this level. A 2005 study of HOT lanes in Santa Clara County compared HOT lane performance and revenue generation under scenarios of 1,500 and 1,650 vph. Values in the range of 1,500 and 1,650 vph have also been applied to value pricing studies on I-15 and I-5 in the San Diego area where multiple-lane HOT facilities are presently in operation or are planned for implementation.

For this study, which assumes a network of single-lane HOT lane facilities, a 1,600 vph threshold was selected as the basis for the initial analysis as the optimum representation of current operating conditions on the region's most successful HOV lanes.

For forecasting future travel, no limit is set on the number of carpools that can use an HOV lane. The forecasts of HOT lane usage set a limit of 1,600 vph of combined HOV and tolled vehicles. After that threshold, no more tolled vehicles are allowed in the HOT lane.

In future study phases, different values may be applied based on more specific knowledge of the facilities under study. It may be important to use different thresholds to test bottlenecks in the system or examine the network or system level demands for links in the network. A more conservative "capacity" may be assumed for purposes of estimating revenue if a more conservative framework for revenue is needed.

1.5 FUTURE HOV LANE VOLUMES AND CROWDING

Review of the regional HOV network suggests HOV lanes will become increasingly crowded over time. HOV lane crowding will need to be addressed whether or not the region pursues HOT lanes because, as they fill, HOV lanes will cease to offer travel time savings and reliable trip times for carpools and express buses. At the same time, the expected level of carpooling is an important consideration in assessing the opportunities for and likely success of HOT lanes. If HOV lane volumes are low, converting to HOT lanes makes good use of excess capacity and improves the overall efficiency of the freeway system while putting in place a management tool. Where carpools fill the lanes, HOT lanes will generate little revenue and may fail to cover their operating costs.

An important threshold in evaluating crowding is the volume at which 85% of the useful capacity of a lane is reached over a significant distance within a travel corridor. The intent in flagging corridors when they reach this threshold is to allow actions to preserve capacity and keep an HOV lane from reaching stop-

[4] Vehicles are classified as passenger car equivalents, which are intended to classify all vehicles using a facility into fractions or multiples of passenger cars depending on size, speed, and other factors.

and-go conditions. For purposes of this analysis, useful capacity is defined to be 1,600 vehicles per hour (vph). This volume corresponds roughly with level of service C and is characterized by relatively free flowing traffic. The threshold for identifying HOV lanes as crowded is 1,360 vehicles per hour per lane (85 percent of 1,600 vehicles per hour) over 20% of the corridor distance.

For purposes of this analysis, corridors are considered candidates for increasing vehicle occupancy when they become crowded according to this definition. While there may be some opportunities to address crowding through other means (spot improvements, adding a second HOV lane), increasing vehicle occupancy is likely to be the most cost-effective response in most corridors. The figure below indicates the approximate date at which HOV lanes are projected to become crowded based on this threshold. (Appendix E includes additional detail, including forecast levels of HOV lane usage on segments within each corridor.)

Corridors projected to become crowded by 2020 include:

- I-80 in Alameda and Contra Costa (37% of the westbound distance in the a.m. peak hour will surpass 1,360 vph by 2016)
- SR 85 (24% of the northbound distance in the a.m. peak hour will surpass 1,360 vph by 2019)
- I-680 in Contra Costa (23% of the southbound distance in the a.m. peak hour will surpass 1,360 vph by 2019)
- I-580 in Alameda (westbound extent of congested distance in the a.m. peak hour not available at this stage)

By 2030, additional corridors will become crowded, including:

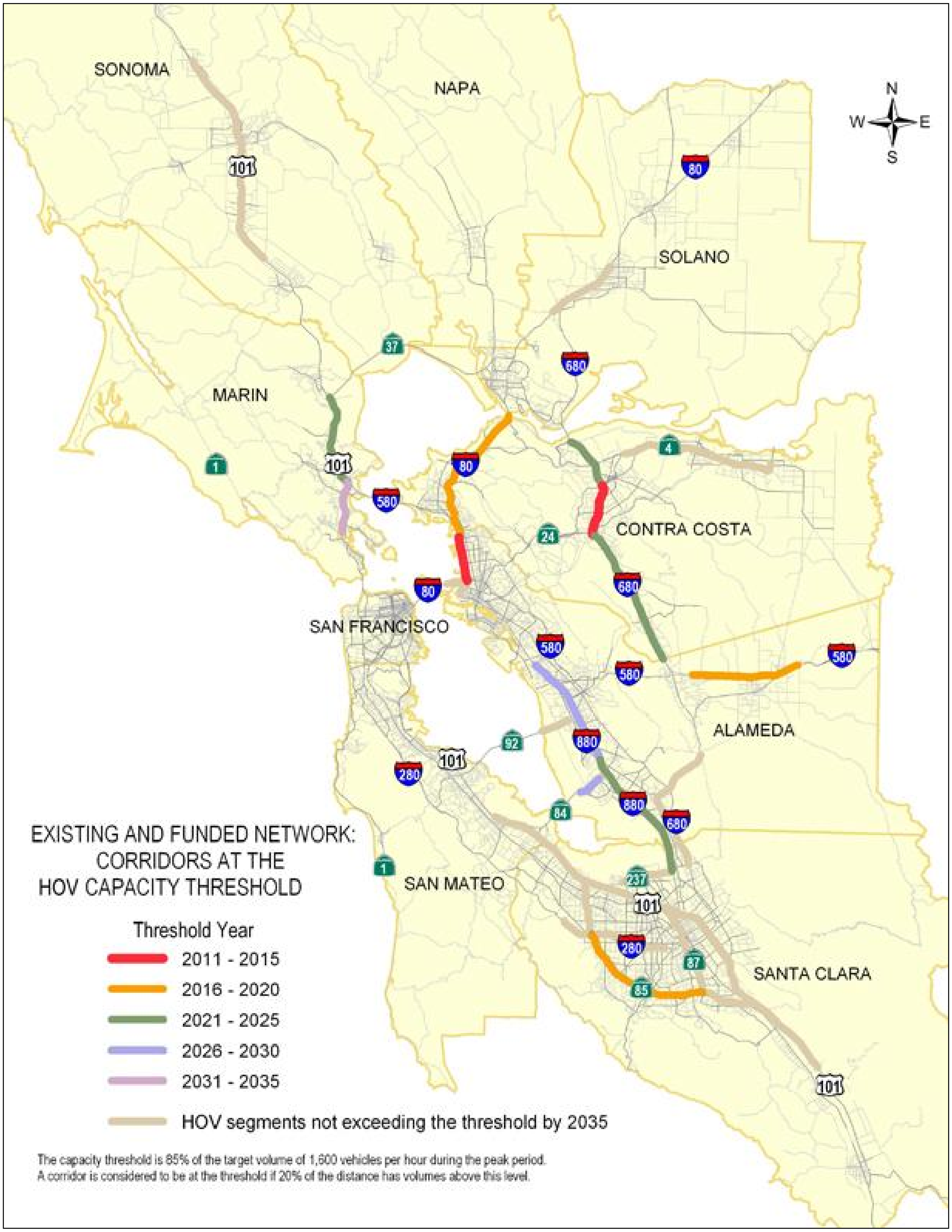
- US 101 Marin and Sonoma (20% of the southbound distance in the a.m. peak hour will surpass 1,360 vph by 2025)
- I-880 Alameda and Santa Clara (34% of the southbound distance in the a.m. peak hour will surpass 1,360 vph by 2026)

As the analysis is refined in future phases of work, it will be important to consider alternative approaches to converting HOV lanes to HOT in light of HOV lane usage trends and freeway management objectives. Three approaches are listed below and discussed in some more detail in the Task 4 report for this study.

1. Convert an HOV lane to a HOT lane before the HOV lane becomes congested
2. Convert an HOV lane to a HOT lane just at the point it is becoming congested and when the HOV occupancy requirement needs to be increased to maintain acceptable travel conditions (perhaps 1,360 to 1,600 vehicles in the peak hour). Open the HOT lane with a tolling policy that allows HOVs to travel free of charge only if they meet the increased occupancy requirement.
3. When the HOV lane begins to get crowded, add a second lane for a total of one HOV and one HOT lane or two HOT lanes.

A principle of this review should be underscored. It is important to preserve the functionality of HOV lanes for their intended purpose of encouraging higher vehicle occupancy travel. By applying a threshold above which tolled vehicles cannot enter the HOT lane, it is possible to maintain priority for high occupancy vehicles. This assures that tolled vehicles will not displace HOVs as carpool volumes grow. However, even without consideration of tolling, growth in HOV volumes will reach a point where HOV lanes become crowded. If crowding is not addressed, the HOV lane will not serve their intended purpose of providing faster, more reliable trips for carpools and express buses.

Figure 1.5-1: HOV Lanes at the Capacity Threshold in the Existing and Funded Network



Source: Caltrans and MTC, 2006

1.6 EXISTING AND FUNDED NETWORK

The Existing and Funded HOT Lanes Network would be developed by converting the HOV lanes planned to be in operation by 2015 to HOT lanes. It includes existing HOV lanes, those under construction, and those funded in the 2007 Transportation Improvement Program (TIP), about 490 lane miles total. (See Figure 1.6-1.) The purpose of considering this 2015 network is to identify the potential costs, revenues, and related information for the HOV routes most likely to be in operation in the next decade or so.

1.6.1 Costs

Costs for developing and operating HOT lanes include capital (e.g., lane or roadway widening and tolling equipment), operations and maintenance (e.g., equipment maintenance, management, and enforcement), and centralized systems (e.g., transaction costs and start-up investments). Each of these has been estimated in 2006 dollars based on Caltrans project study reports, planning conducted by ACCMA and VTA, Bay Area Toll Authority (BATA) experience, and experience elsewhere.

1.6.1.1 Capital Costs

Capital cost estimates are based on modifications needed to convert an HOV lane to a HOT lane. These include: adding the signs and toll readers, adding right-of-way and pavement where needed, modifying structures, and managing traffic during construction. The cost estimates were reviewed with Caltrans, the ACCMA and the technical group for adequacy and determined to be sufficient.

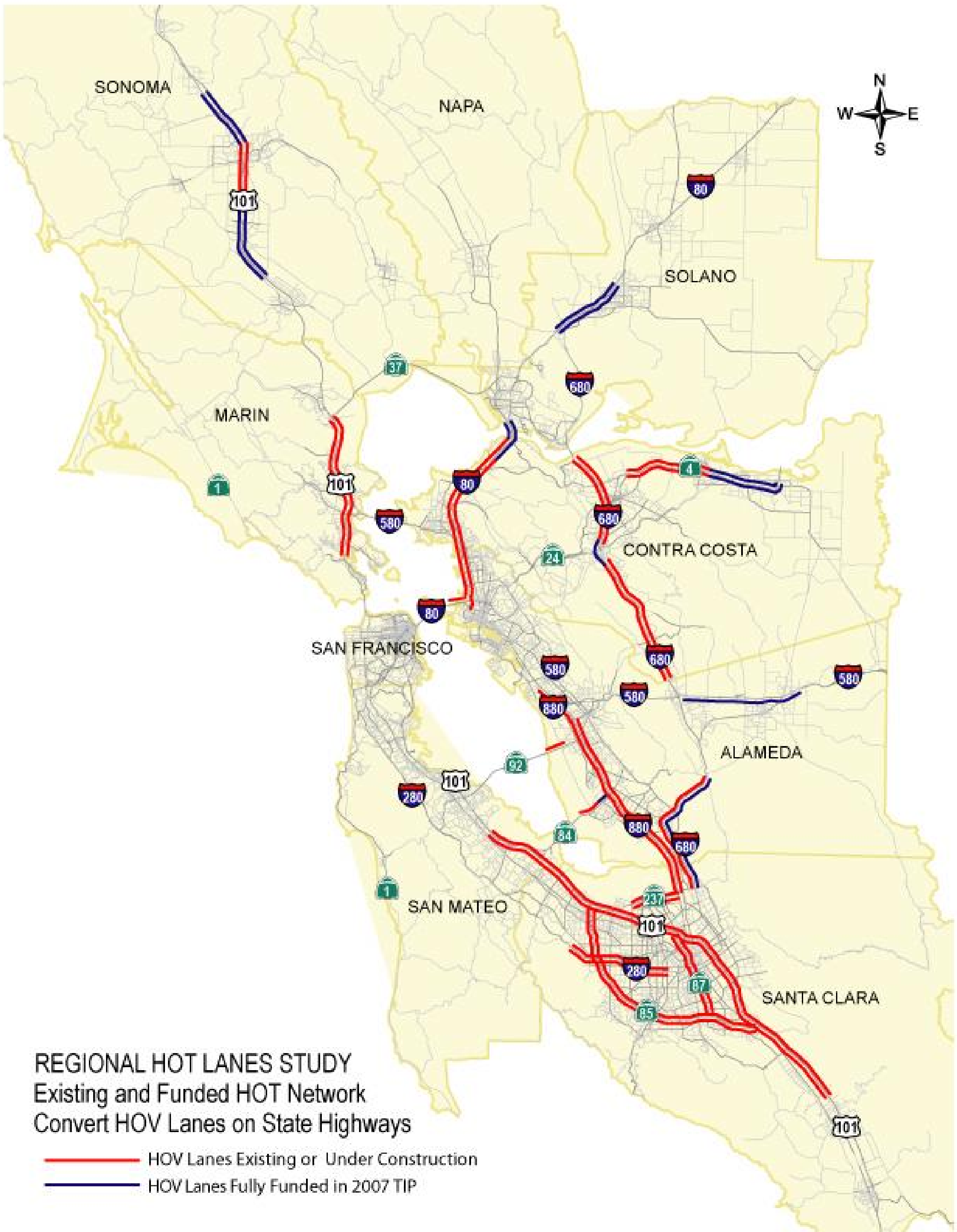
The extent of facility modifications required to accommodate an HOT lane differs from corridor to corridor and within a given corridor depending on the age of the freeway, number of structures and paved right-of-way. Thus, high, medium and low unit costs were developed to reflect the range of modifications likely to be required:

- Low Range – No widening needed; no structures to be replaced; 20% contingency; $1.4 million per lane-mile
- Mid Range – Some widening needed; 1.5 bridges per lane mile to be modified; 30% contingency; $2.2 million per lane-mile
- High Range – More widening needed; 2.5 bridges per lane mile to be modified; 40% contingency; $3.7 million per lane-mile

The capital cost for developing the Existing and Funded Network is approximately $1.2 billion (in 2006 dollars). Where a Caltrans project study report (PSR) documented corridor-specific engineering features or constraints, this information was used to evaluate whether that corridor would be considered to have a low-, mid- or high-range unit cost. Where no PSR was available, the unit cost ranges were selected based on an engineer's inspection of Google™ Earth photos and, in some cases, review with local agencies. Where no project study report was available, the unit costs above were considered for the HOT lane corridors and applied based on engineers' inspection of Google Earth photos and, in some cases, review with local agencies. Segments with sufficient right-of-way and very few structures were costed at the low level. Depending on right-of-way availability, extent of structures, and other factors, higher unit costs were applied in other segments.

Appendix A includes a more detailed breakdown of the unit costs. Appendix B presents the capital cost estimate for each corridor in the Existing and Funded HOT lane network, including a summary of how the unit costs were applied.

Figure 1.6-1: Existing and Funded HOT Lane Network



Source: Caltrans and MTC, 2006.

1.6.1.2 Operating and Maintenance Cost

Operations and maintenance (O&M) costs are estimated at $70,000 per lane-mile per year. This estimate is based on planning by ACCMA for the I-680 HOT lane. It includes the following costs proportional to corridor distance: a) maintenance of toll equipment; b) supplies; c) utilities; d) lease of communications system; and, e) enforcement. Enforcement unit costs for the system, however, may differ from those for a single corridor. Administrative costs and a 25% contingency are added to these items resulting in the $70,000 operations and maintenance cost per lane-mile.

It is noted that the annual operating and maintenance cost associated with the pavement itself is not included in this estimate.

The annual operations and maintenance cost for the 490 lane-miles included in the Existing and Funded Network (at $70,000 per lane mile per year; not including the pavement O&M), is about $34 million per year (in 2006 dollars).

1.6.1.3 Centralized Costs

Centralized system costs are a factor of HOT lane usage and are not proportional to corridor length. These include: the cost to BATA for processing a tolling transaction, estimated to be $0.16 per transaction; 2.2% of transaction costs for bank or financial institution processing fees; and $18 each for purchase and replacement of a transponder. In addition, the centralized system costs include a one time start up cost of $1 million to expand BATA operations from the current scale, designed to handle traffic on the seven state-owned toll bridges, to one capable of handling traffic on a regional HOT lane network.

1.6.2 HOT Lane Traffic Characteristics in 2015 and 2030

An important issue concerns the use of HOT lanes and their effect on the rest of the freeway system. Forecasts from the MTC travel demand model and the toll optimization model provide information on vehicle miles of travel, vehicle hours of travel, and speed that help demonstrate how vehicle travel might shift with the addition of HOT lanes. It is important to consider the information presented here as illustrative of the conditions that may arise with the development of a HOT lane network. Future study phases will allow more detailed analysis than is possible based on the somewhat simplified forecasting conducted to date. (See discussion in Section 1.3.) Table 1.6-1 shows a.m. peak hour travel statistics for the Existing and Funded HOT Lane Network compared to those if the network were developed as an HOV system only. Appendix F presents a.m. peak hour vehicle volumes in the HOT lanes and general purpose lanes.

Table 1.6-1 presents the initial regional estimates of VMT, VHT and a.m. peak hour average speeds for the region with HOV-only lanes and with those lanes managed as HOT lanes.[5] The data is presented for the HOV or HOT lane(s), the general purpose lanes and for all of the lanes combined. Key observations include the following:

- Converting HOV lanes to HOT lanes and using today's HOV occupancy requirements is forecasted to have little effect on overall network VMT. However, this conversion reduces VMT in the general purpose lanes by approximately 10%, and increases VMT (and usage) of the HOV lanes by 55% to 74% depending upon the horizon year (2030 and 2015 respectively). The 2030 scenario sees less of a gain in VMT using the HOV/HOT lanes because 15 years of overall travel growth has increased the use of the lanes.

[5] Note that the HOT lane speeds are generated by a dynamic pricing model. The speeds under the HOV policy come from a single run of the regional model (implicitly static). In future project evaluations, there will be opportunities to estimate HOV lane speeds that take into account changes in HOV volumes (as a result of added HOV lanes and introduction of tolled vehicles into the HOV lanes). In addition, the estimation of the volumes of tolled vehicles will, then, be based on more representative traveler behavior.

- There is a more pronounced effect on VHT than on VMT. While there is a significant increase in HOV/HOT lane VHT (almost a doubling), there is a 15% reduction in total VHT for the corridors and the effect on general purpose lanes is significant, with a 23% reduction in VHT.
- Travel in the HOT lane is slightly faster than in the general purpose lanes. As the HOT lanes are expected to carry more vehicle trips than do today's HOV lanes, it can be expected that the speeds will be slightly lower than experienced today. However, because volumes in the HOT lanes are not permitted to exceed 1,600 vehicles per hour, HOT lane speeds remain relatively high, well above 50 miles per hour.

Comparing the Existing and Funded Network speeds in 2030 shows patterns similar to those of 2015. Overall, speeds in the HOV and general purpose lanes slow from 2015 to 2030. However, the speeds in the general purpose lanes slow more than do those in the HOT lanes, indicating that the HOT lanes are likely to be seen as more valuable as time passes.

Table 1.6-1: Existing and Funded HOT Network Performance With and Without HOT Lanes (1)

	2015			2030		
	HOV/HOT Lanes	General Purpose Lanes	Total All Lanes	HOV/HOT Lanes	General Purpose Lanes	Total All Lanes
AM Peak Hour Vehicle Miles Traveled (VMT)						
HOV only	323,400	2,381,800	2,705,200	395,600	2,576,800	2,972,400
HOT lanes	564,100	2,139,000	2,703,100	612,500	2,352,200	2,969,700
pct change	74%	-10%	0%	55%	-9%	0%
AM Peak Hour Vehicle Hours Traveled (VHT)						
HOV only	5,330	63,560	68,890	6,940	82,840	89,780
HOT lanes	10,160	48,630	58,800	11,530	64,390	75,910
pct change	91%	-23%	-15%	66%	-22%	-15%
AM Peak Hour Average Speed (2)						
HOV only	61	37	39	57	31	33
HOT lanes	56	44	46	53	37	39
pct change	-9%	15%	15%	-8%	15%	15%

(1) Figures are for miles of freeways with HOV or HOT lanes only and reflect results of analysis assuming existing HOV occupancy requirements for HOV and HOT lanes.

(2) Reflects travel in the peak and reverse peak direction.

1.6.3 Revenue in 2015 and 2030

A tolling model was used to estimate tolls and revenue based on MTC travel model forecasts. Estimates of average annual revenue for the Existing and Funded Network in 2015 and 2030 are provided in Table 1.6-2 on the following page. These estimates are approximations useful at a general planning level but needing more refinement prior to project development. In particular, these forecasts, which do not have the benefit of feedback between the tolling model and travel demand model, do not account for adjustments travelers would make in response to changes in travel speeds, times, and other factors that come about with implementation of the HOT lanes.

It is useful to note the following when reviewing revenue forecasts by corridor in the table on the previous page:

- In general, corridors that have high levels of congestion in the general purpose lanes and relatively low numbers of carpools in the HOT lanes will generate higher annual toll revenue per mile.
- Most corridors show increasing revenue from 2015 to 2030, reflecting increases in congestion as traffic grows over time. Exceptions to the rule include: I-680 southbound in Contra Costa at a 2+ HOV requirement, I-880 in Alameda and Santa Clara southbound at a 2+ HOV occupancy and SR 84 in Alameda westbound to the toll plaza at a 2+ HOV occupancy. The decrease in revenue for these three is likely due to the HOV lanes becoming more congested over time, leaving very little room for tolled vehicles. When those same corridors are considered at a 3+ occupancy level, revenues grow from 2015 to 2030.
- All corridors would generate higher revenues under a 3+ vehicle occupancy requirement than under a 2+ requirement because there is more room for toll-paying vehicles. In addition, 2-person carpools would pay tolls to use HOT lanes under a 3+ vehicle occupancy policy, and they are typically willing to pay higher toll rates since the cost is shared between the two occupants.
- Some corridors have estimated average annual revenues in 2030 at greater than $1 million per mile, including:
  - I-680 southbound in Alameda-Santa Clara
  - I-680 southbound in Contra Costa (at 3+ only)
  - I-880 in Alameda-Santa Clara in both directions
  - SR 237 eastbound in Santa Clara
  - SR 87 in both directions in Santa Clara County
  - US 101 southbound in San Mateo and Santa Clara in most conditions and northbound at a 3+ occupancy requirement

These revenue ranges must be considered in relation to capital, operations and maintenance, and centralized system costs. That relationship is addressed in Section 1.9.

Table 1.6-2: Existing and Funded Network – Average Annual Revenue/Mile in 2015 and 2030 (Thousands of 2005 Dollars)

		2015		2030	
Corridor	**Direction**	**HOV 2+**	**HOV 3+**	**HOV 2+**	**HOV 3+**
SR 4 CC	EB	$2	$11	$74	$138
SR 4 CC	WB	$105	$278	$207	$743
I-80 ALA-CC	EB	NA	$514	NA	$3,055
I-80 ALA-CC	WB	NA	$653	NA	$1,101
I-80 SOL	EB	$51	$104	$327	$609
I-80 SOL	WB	$77	$266	$291	$1,097
SR 84 ALA (Dumbarton Bridge approach)	WB	$249	$873	$146	$1,591
SR 85 SC	NB	$42	$217	$77	$703
SR 85 SC	SB	$211	$326	$315	$564
SR 87 SC	NB	$959	$1,957	$2,987	$8,162
SR 87 SC	SB	$271	$485	$1,177	$2,418
SR 92 ALA (San Mateo Bridge approach)	WB	$349	$903	$460	$1,890
US 101 SM-SC	NB	$700	$1,751	$842	$5,642
US 101 SM-SC	SB	$434	$1,012	$1,166	$4,517
US 101 MAR-SON	NB	$20	$35	$51	$92
US 101 MAR-SON	SB	$45	$134	$103	$608
SR 237 SC	EB	$134	$209	$1,038	$1,813
SR 237 SC	WB	$313	$645	$601	$3,564
I-280 SC	NB	$133	$265	$256	$569
I-280 SC	SB	$109	$179	$241	$405
I-580 ALA	EB	$36	$80	$680	$1,380
I-680 ALA-SC	NB	$86	$462	$599	$2,235
I-680 ALA-SC	SB	$1,725	$3,130	$4,667	$17,521
I-680 CC	NB	$340	$793	$593	$1,285
I-680 CC	SB	$165	$1,009	$90	$2,112
I-880 ALA-SC	NB	$683	$2,289	$1,283	$4,090
I-880 ALA-SC	SB	$1,213	$3,549	$1,065	$8,942
I-880 ALA Bay Bridge approach	NB	NA	$19	NA	$63

1.6.4 Sensitivity Tests and Special Analyses of Revenue

1.6.4.1 Sensitivity Tests

The revenue estimates for this study depend on numerous policy and modeling assumptions. Some of the chief assumptions include: (1) A tolling objective to maximize the value of travel time savings across all users, subject to a maximum volume of 1,600 vehicles per hour in the HOT lane; (2) hybrid vehicles do not receive special treatment with respect to tolls; and (3) HOT lane operations 24 hours a day, seven days a week (for a more thorough discussion of assumptions, see Section 1.3.). Several sensitivity tests were conducted to illustrate the impact on revenues of other tolling and operation policies. These are summarized briefly below:

1. The adoption of tolling objectives. In analysis performed for other HOT lane corridors, tolls set under a revenue maximizing objective have been shown to generate revenues at least 20 percent greater during the AM peak period compared with those obtained under an objective to minimize the aggregate cost of travel time. Moving to an objective which seeks to maintain a target level of vehicles on the HOT lane equal to the maximum vehicles per hour per HOT lane has been shown to result in AM peak period revenues at least 10 percent lower on average when compared with the approach used here. The difference in revenue performance of the alternative objectives is amplified in corridors that experience heavy congestion.
2. The adoption of a policy that would allow hybrid vehicles to use the HOT lane for free or at a discount. If hybrids are eventually treated equivalently with carpools for the purpose of HOT lane access, this could limit the amount of capacity available to sell and lower revenues from those forecast here. Allowing hybrids to travel in the HOT lanes for free could reduce revenue by 5 to 40 percent depending upon the corridor.
3. Sensitivity of revenues to limited hours of operation. Table 1.6-3 below provides a rough estimate of the percent share of all-day revenues obtained when HOT lane pricing is limited to the most heavily congested weekday and weekend hours. For instance, if HOT lane pricing is limited to the 8 most heavily congested weekday hours/day and 4 most heavily congested weekend hours/day, we would expect on average that 71 percent of the revenues obtained under all-day pricing would be realized. The figures below are based on generalized information about congestion patterns over the course of a day or week and will need to be refined through more detailed analysis corridor by corridor. The actual sensitivity of limited hours may, in the end, vary significantly by corridor.

Table 1.6-3: Average Share of All-Day Revenues Obtained Under Limited Hours of Operation

Hours Operated per Day on Weekdays	*And Hours Operated per Day on Weekends*				
	4	**8**	**12**	**16**	**24**
4	48%	56%	61%	62%	62%
8	71%	80%	84%	85%	85%
12	82%	91%	95%	96%	96%
16	86%	94%	99%	100%	100%
24	86%	94%	99%	100%	100%

1.6.4.2 Special Review of Potential Increased Occupancy Requirement for I-80 in 2015

HOT lane operations on I-80 in Alameda and Contra Costa counties merit special consideration since forecasts show these carpool lanes filling up as soon as 2015 under the existing 3+ HOV occupancy requirement in place in this corridor. In particular, it is important to consider options that can help manage crowding in the carpool lane. One option would be to toll 3-person carpools either the full HOT lane toll rate or a reduced rate. For illustrative purposes only, this study considered the impact of allowing only buses and vanpools to travel free and charging 3-person carpools the full toll rate between the Carquinez Bridge and the Bay Bridge.

A key assumption concerns the number of vehicles that could be expected to use the westbound HOV lane. Based on review of current vanpooling and bus service in the corridor, an estimate was made that approximately 60 buses per peak hour and 70 vanpools per peak hour could be assumed to operate in the HOV lane in 2015. This allows for a level of vanpooling and bus service over that in the lane today.

Table 1.6.4 includes estimates of average annual revenue per mile, average hourly revenue per mile in the a.m. peak, and average toll per mile (only average annual revenue per mile is available for both the westbound and eastbound directions). The review of these two tables leads to the following preliminary observations concerning I-80 in the westbound direction between the Carquinez and Bay Bridges:

- The approach could double the annual revenue for the corridor because it significantly reduces the number of free vehicles in the HOT lane while the general purpose lanes remain highly congested.
- Average hourly revenue per mile can be expected to increase significantly (estimated at a 90% increase for the westbound corridor).
- The average toll per mile can be expected to increase slightly (about 5% for the westbound corridor).
- The average a.m. peak period westbound speeds in the general purpose and HOV lanes are not expected to change significantly by the increase in vehicle occupancy. This suggests that the net shift of carpools to the general purpose lane is more or less offset by the addition of new tolled vehicles into the HOT lane.

Table 1.6-4: I-80 in 2015 – Review of Increased Vehicle Occupancy Condition

	HOV as 3+ Occupancy	HOV as Vanpool/Bus Only	Difference
Average annual revenue per mile westbound (millions)	$ 653	$ 1,331	104%
Average annual revenue per mile eastbound (millions)	$ 514	$ 1,048	104%
Average hourly revenue per mile in a.m. peak hour westbound (millions)	$ 892	$ 1,695	90%
Average toll per mile westbound	$ 0.56	$ 0.59	5%

Note: Average hourly revenue per mile in a.m. peak and average toll per mile not available for eastbound lanes

Table 1.6-5: I-80 Westbound in 2015 – Effect of Increased Vehicle Occupancy Requirement Effect on Speeds in the General Purpose and HOV Lanes

	HOV as 3+Occupancy		HOV as Vanpool/Bus Only	
	General Purpose	HOT	General Purpose	HOT
Average speeds during a.m. peak period	45	54	44	55

1.7 CONNECTED NETWORK

The Connected HOT Lane Network includes HOV lanes planned to be in operation by 2030 – on the basis of their inclusion in the regional long range plan *Transportation 2030* – as well as additional segments and freeway-to-freeway connectors which together form a highly connected and expansive regional network (see Figure 1.6-2.). The network includes approximately 790 lane miles of HOT lanes. Except for the extensions to the outermost edges of the region on US 101, I-80 and I-580, all of the segments are included in the 2002 MTC HOV Master Plan. However, most of the segments which do not include HOV lanes in *Transportation 2030* are considered "Priority 2" investments in the HOV Master Plan and have been subjected to limited additional planning, if any. The purpose of considering this 2030 network is to identify the potential costs, revenues, and related information for a highly connected or continuous network throughout the Bay Area.

By identifying the costs and revenues associated with the Connected Network for 2030, MTC and its partners were provided a sense of the benefits from a truly connected HOV/HOT network. The analysis indicated whether there may be revenues available to expand the HOV and HOT system and, perhaps, help fund express bus and related services.

1.7.1 Costs

1.7.1.1 Capital Costs

Cost estimates for the for the Connected Network are based generally on the same methodology and HOT lane unit costs used for the Existing and Funded Network and are given in 2006 dollars (see section 1.6.1). Where available, existing project study reports (PSRs) for HOV projects were used to as the basis for developing cost estimates.

However, unlike the Existing and Funded Network, the Connected Network includes several segments with currently unfunded HOV lane extensions and gap closures to be developed after 2015. As a result, the capital cost estimate for the Connected Network includes the cost of widening for HOV travel lanes, as well as the cost for HOT lane elements in these segments. The cost of widening for HOV lanes not included in the Existing and Funded network, and where PSRs were not available, is estimated to be $8 million per lane mile. This cost for HOV construction is added to the unit costs for HOT lane elements described in section 1.6.1 and outlined in Appendix A. It is likely that developing the HOV and HOT elements simultaneously will lead to cost savings. At this early stage, accounting for both costs with no assumption of economies or savings results in a conservative capital cost assumption.

The incremental capital cost for expanded from the Existing and Funded HOT Lane Network to the Connected HOT Lane Network is approximately $3.6 billion (see Appendix C). The estimated cost for the HOT lane features alone is $660 million of this total. The balance of $2.9 billion is for addition of HOV lanes (at $8 million per lane mile) for the 297 lane miles of HOV lanes to be added after 2015. Appendix D shows a total capital cost of almost $4.8 billion for the entire 2030 Connected Network, including those segments in the Existing and Funded Network.

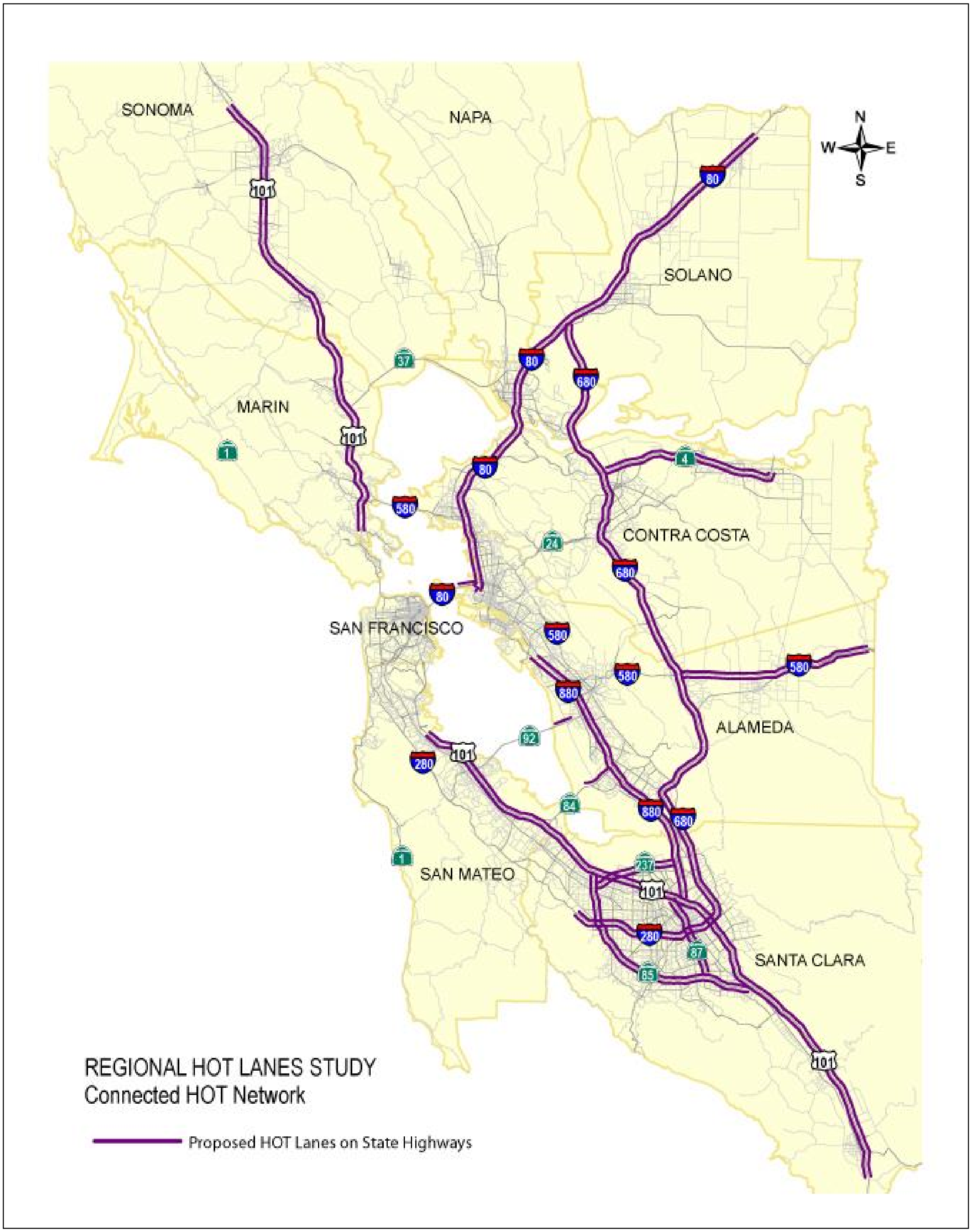
1.7.1.2 Operating and Maintenance Costs and Centralized Costs

Operations and maintenance costs ($70,000 per lane mile per year) and centralized system costs applied to the Existing and Funded Network are applied to the Connected Network as well (see section 1.5.1).

It is noted that the annual operating and maintenance cost associated with the pavement itself is not included in this estimate.

The annual operations and maintenance cost for lanes added after 2015 in the Connected Network (at $70,000 per lane mile per year), is about $21 million per year. Thus the total for the entire Connected Network is $55 million per year.

Figure 1.6-2: Connected HOT Lane Network



Source: Caltrans and MTC, 2006

1.7.2 HOT Lane Traffic Characteristics in 2030

The Connected Network has traffic impacts fairly similar to those of the Existing and Funded Network. Table 1.6-1 compares a.m. peak hour VMT, VMT, and speeds for the Connected HOT Lane Network in 2030 with those assuming the network were built as an HOV lane system only. Appendix F presents a.m. peak hour volumes in the HOT and general purpose lanes.

As noted in Section 1.6.2, it is important to consider the information presented here as illustrative of the conditions that may arise with the development of a HOT lane network. Future study phases will allow more detailed analysis than is possible based on the somewhat simplified forecasting conducted to date (see discussion in Section 1.3).

Table 1.7-1: Connected HOT Network Performance With and Without HOT Lanes (1)

		2030		
		HOV/HOT Lanes	**General Purpose Lanes**	**Total All Lanes**
AM Peak Hour Vehicle Miles Traveled (VMT)				
	HOV only	581,000	3,926,000	4,507,000
	HOT lanes	970,000	3,735,000	4,705,000
	pct change	67%	-5%	4%
AM Peak Hour Vehicle Hours Traveled (VHT)				
	HOV only	10,410	120,890	131,290
	HOT lanes	17,960	95,615	113,575
	pct change	73%	-21%	-13%
AM Peak Hour Average Speed (2)				
	HOV only	56	32	34
	HOT lanes	54	39	41
	pct change	-3%	20%	21%

(1) Figures are for miles of freeways with HOV or HOT lanes only and reflect results of analysis assuming existing HOV occupancy requirements for HOV and HOT lanes.

(2) Reflects travel in the peak and reverse peak direction.

Table 1.7-1 presents the initial regional estimates of VMT, VHT and a.m. peak hour average speeds for the Connected Network with HOV-only lanes and with those lanes managed as HOT lanes. The data is presented for the HOV or HOT lane(s), the general purpose lanes and for all of the lanes combined. Key observations include the following:

- Development and operation of HOT lanes on the Connected Network regional freeway system reduces VMT in the general purpose lanes modestly and shifts this travel to the HOT lanes resulting in an overall slight increase of VMT.
- Development and operation of HOT lanes on the Connected Network regional freeway system reduces travel delay in the general purpose lanes by over 20% while increasing travel delay in the HOT lanes, but not to the point of unacceptable operating levels of delay. For all lanes in the regional network, the vehicle hours traveled decreases by 13%.

- Development and operation of HOT lanes on the Connected Network regional freeway system has the net effect of moving some traffic from the general purpose lanes to the HOT lane and doing so in a manner that keeps the HOT lane from overcrowding. This results in somewhat fewer vehicle trips in the general purpose lanes, which results in an increase in the general purpose lane operating speeds. However, it should be noted that future analysis may consider shifting of traffic from adjoining corridors or earlier or later travel times, thus the increase in speeds may be offset.
- As a result of introducing tolled vehicles into the lane, travel speeds in the HOV/HOT lane can be expected to slow somewhat but not reach breakdown conditions. As more high occupancy vehicles use the lane, volumes are expected to increase in several corridors sufficient to cause consideration of increasing the vehicle occupancy requirement.

1.7.3 Revenue in 2030

As discussed for the Existing and Funded Network, a tolling model was used to estimate tolls and revenue based on MTC travel model forecasts. Table 1.7-2 (on the following page) presents estimates of average annual revenue for the Connected Network in 2030. These estimates are approximations useful at a general planning level but needing more refinement prior to project development. In particular, these forecasts, which do not have the benefit of feedback between the tolling model and travel demand model, do not account for adjustments travelers would make in response to changes in travel speeds, times, and other factors that come about with implementation of the HOT lanes.

Table 1.7-2: Connected Network – Average Annual Revenue/Mile in 2030 (Thousands of 2005 Dollars)

		2030	
Corridor	**Direction**	**HOV 2+**	**HOV 3+**
SR 4 CC	EB	$29	$53
SR 4 CC	WB	$115	$414
I-80 ALA-CC	EB	NA	$621
I-80 ALA-CC	WB	NA	$634
I-80 SOL east of Vallejo	EB	$927	$1,499
I-80 SOL east of Vallejo	WB	$683	$2,066
I-80 SOL through Vallejo	EB	$132	$225
I-80 SOL through Vallejo	WB	$215	$307
SR 84 ALA (Dumbarton Bridge approach)	WB	$163	$1,718
SR 85 SC	NB	$76	$436
SR 85 SC	SB	$401	$717
SR 87 SC	NB	$780	$1,345
SR 87 SC	SB	$200	$416
SR 92 ALA (San Mateo Bridge approach)	WB	$492	$2,143
US 101 SM-SC	NB	$662	$4,473
US 101 SM-SC	SB	$725	$3,450
US 101 SM	NB	$803	$2,611
US 101 SM	SB	$656	$1,951

		2030	
Corridor	**Direction**	**HOV 2+**	**HOV 3+**
US 101 MAR-SON	NB	$80	$144
US 101 MAR-SON	SB	$126	$714
SR 237 SC	EB	$748	$1,345
SR 237 SC	WB	$514	$2,676
I-280 SC	NB	$194	$1,763
I-280 SC	SB	$432	$1,066
I-580 ALA	EB	$480	$1,351
I-580 ALA	WB	$168	$2,192
I-680 ALA-SC	NB	$303	$1,394
I-680 ALA-SC	SB	$1,147	$7,669
I-680 CC	NB	$635	$1,394
I-680 CC	SB	$61	$2,666
I-680 SOL	NB	$63	$91
I-680 SOL	SB	$81	$199
I-880 ALA-SC	NB	$805	$2,513
I-880 ALA-SC	SB	$953	$4,370
I-880 ALA Bay Bridge Approach	NB	NA	$22

Several points are of note when reviewing forecasts of average annual revenue per mile by corridor for the Year 2030 Connected Network:

- As was true for the Existing and Funded Network, all corridors would generate higher revenues under a 3+ vehicle occupancy requirement than under a 2+ requirement.
- In several corridors for which the Connected Network includes HOT lane extensions, the average annual toll revenue per mile in 2030 is lower in the Connected Network than it was in the Existing and Funded Network. These include: SR 4, SR 237, I-280, and I-680. This may reflect the fact that the additional segments are less productive in terms of revenue than those in the Existing and Funded Network. However, it may also reflect some redistribution of trips as the HOV/HOT lane network becomes more connected.
- 37% of the corridors would generate over $500,000 per year in average annual revenues at 2+ vehicle occupancy and 69% of the corridors exceed $500,000 per year at 3+.
- 21 of the 35 directional corridors considered have average annual revenue of over $1 million per mile at a 3+ occupancy requirement but only one does at the 2+ level.
- Findings from the sensitivity analyses discussed relative to the Existing and Funded Network revenue estimates in Section 1.6.4 also apply to the estimates for the Connected Network.

These revenue ranges must be considered in relation to capital, operations and maintenance, and centralized system costs. That relationship is addressed in Section 1.9 below.

1.8 NETWORK CONSIDERATIONS

1.8.1 Connectivity

A principal goal in building a regional HOT network is to connect and extend the existing HOV system. Connecting the system through filling gaps and building direct connectors has two benefits from perspectives of both travelers and system owner/operators. A connected network provides better service to HOT lane users, including express buses and carpools, by reducing the need to travel in the general purpose lanes. This increases travel time reliability. From the perspective of the system owner or operator, connecting the network eliminates merges where HOT lanes end and therefore reduces the chance of merge-related bottlenecks and accidents.

Gap closures are additions of HOV and HOT lanes that link two adjoining HOV or HOT lane segments on the same facility. Gap closures considered in this study are listed in the table below and shown in Figure 1.8-1. Note that extensions of HOV and HOT lanes that do not close gaps are not included in this list. They are listed in a separate table that follows.

Table 1.8-1: Gap Closures

Gap Closures in the Existing and Funded 2015 Network(1)	Gap Closures in the 2030 Connected Network(2)
I-680 southbound from Livorna to North Main Street	US 101 from Old Redwood Highway in Petaluma to SR 37 in Marin County
SR 84 extension to I-880 from the easterly terminus of lanes approaching the Dumbarton Bridge	I-80 from I-680 in Solano County south to the northern end of the Carquinez Bridge in Vallejo
	SR 4 from Port Chicago Highway to I-680 in Contra Costa County
	I-680 from I-80 in Solano County to the southern end of the Benicia-Martinez Bridge
	I-680 from the Alcosta Blvd. south to SR 84
	I-680 from SR 237/Calveras to US 101
	SR 237 from Mathilda Avenue to SR 85
	I-280 from Leland to US 101

(1) Close gaps in the network that exist or is under construction in 2005

(2) Close gaps that would remain in the Existing and Funded Network

This study mainly considers direct connectors between HOV or HOT lanes on freeways. A direct connector is a facility that connects HOV or HOT lanes on intersecting facilities. Just three such facilities currently exist in the Bay Area: (1) the US 101/SR 85 interchange in Mountain View; (2) the US 101/SR 85 interchange in south San Jose; and (3) the I-880/SR 237 interchange in Milpitas.

Direct access HOV or HOT on- and off-ramps constitute another class of direct connectors that are not explicitly considered in this phase of the study. Direct access HOV ramps currently exist at Cutting Boulevard on I-80. Additional direct HOV connectors are recommended in the 2002 HOV Master Plan; however only one, Bollinger Canyon Road on I-680 in San Ramon, is fully funded at this time, and is thus included in the Existing and Funded Network.

As HOT lane designs are refined, particular attention should be given to freeway-to-freeway HOV/HOT connectors due to their potentially significant costs. While direct connectors can considerably reduce travel time and increase reliability advantages offered by HOV and HOT lanes, the cost of adding direct connectors to existing interchanges can be quite high because they often, though not always, involve complicated new structures, structural enhancements to existing interchange ramps and acquisition of additional right of way. As the examples below illustrate, each case tends to be site specific, and needs to rely on early feedback from Caltrans to identify any feasible solutions.

The experience of the Los Angeles Metropolitan Transportation Authority with the I-10/I-605 HOV connector illustrates the potential challenges. What began as an HOV connector with an initial construction cost estimate of $20 million grew to be a full interchange reconstruction costing $289 million. As the project went through successive reviews, substandard design elements were identified as needing to be replaced or upgraded.

In contrast, VTA working with Caltrans has been able to construct three direct HOV connectors at a cost significantly less than full or partial reconstruction of the interchange cost in recent years: SR 237/I-880, SR 85/US 101 in Mountain View and SR 85/US 101 in South San Jose. For example, the SR 237/I-880 connector, which opened to traffic in 2005, was incorporated into the existing interchange without rebuilding other ramps and roadways and at a cost of $11 million.

Direct connectors considered in this study are listed below and shown in Figure 1.8-2.

Table 1.8-2: Direct Connectors

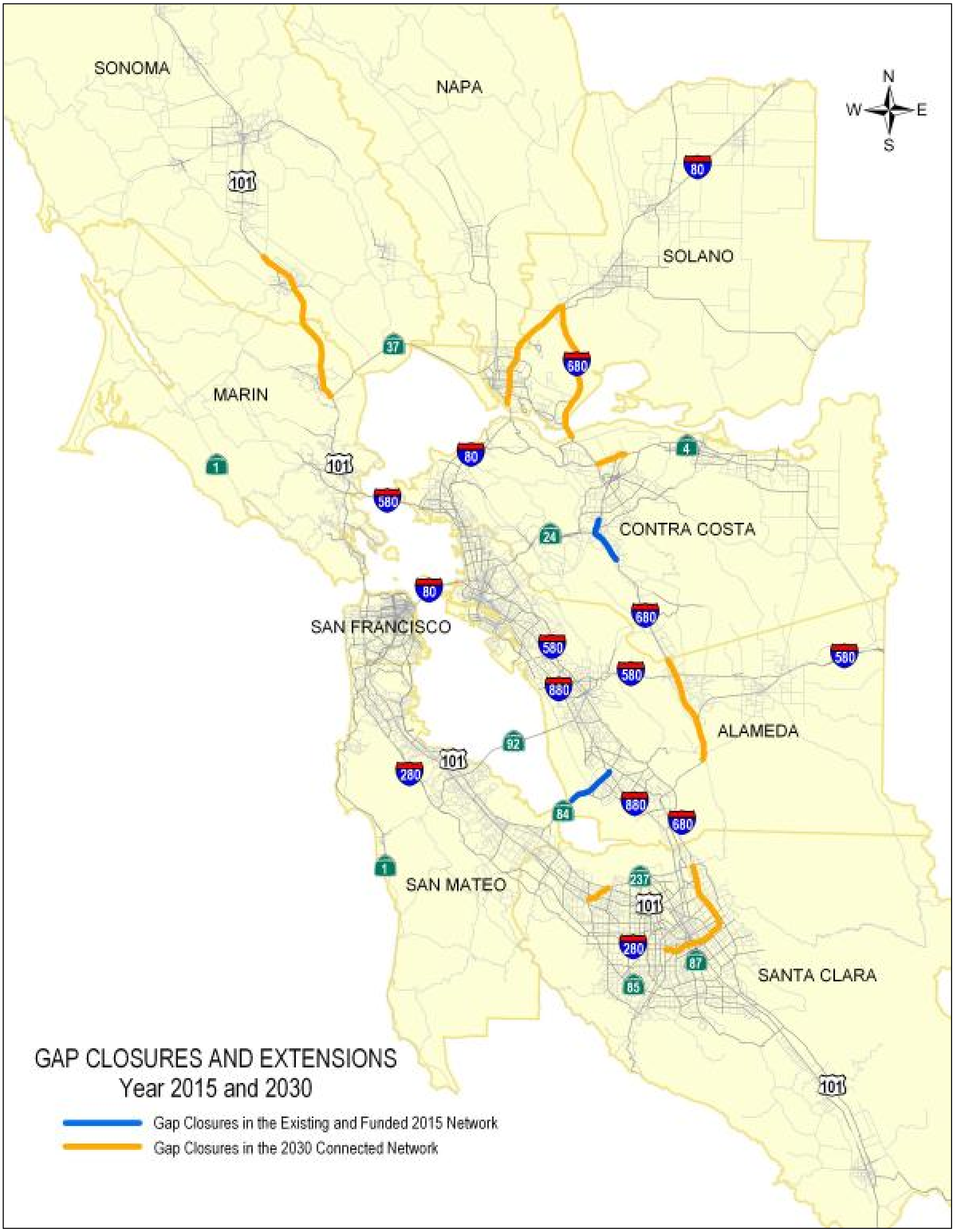
Direct Connectors in the Existing and Funded 2015 Network	Direct Connectors in the Connected 2030 Network
US 101/SR 85 (Mountain View)	I-680 interchange with SR 4
US 101/SR 85 (south San Jose)	I-680 interchange with I-580
I-880/SR 237 (Milpitas)	I-680 interchange with I-80

Though not a connectivity issue per se, extensions of HOV lanes enable a greater “reach” for the HOV and HOT system. The extensions of HOV/HOT lanes considered in this review are summarized below.

Table 1.8-3: HOV/HOT Lane Extensions

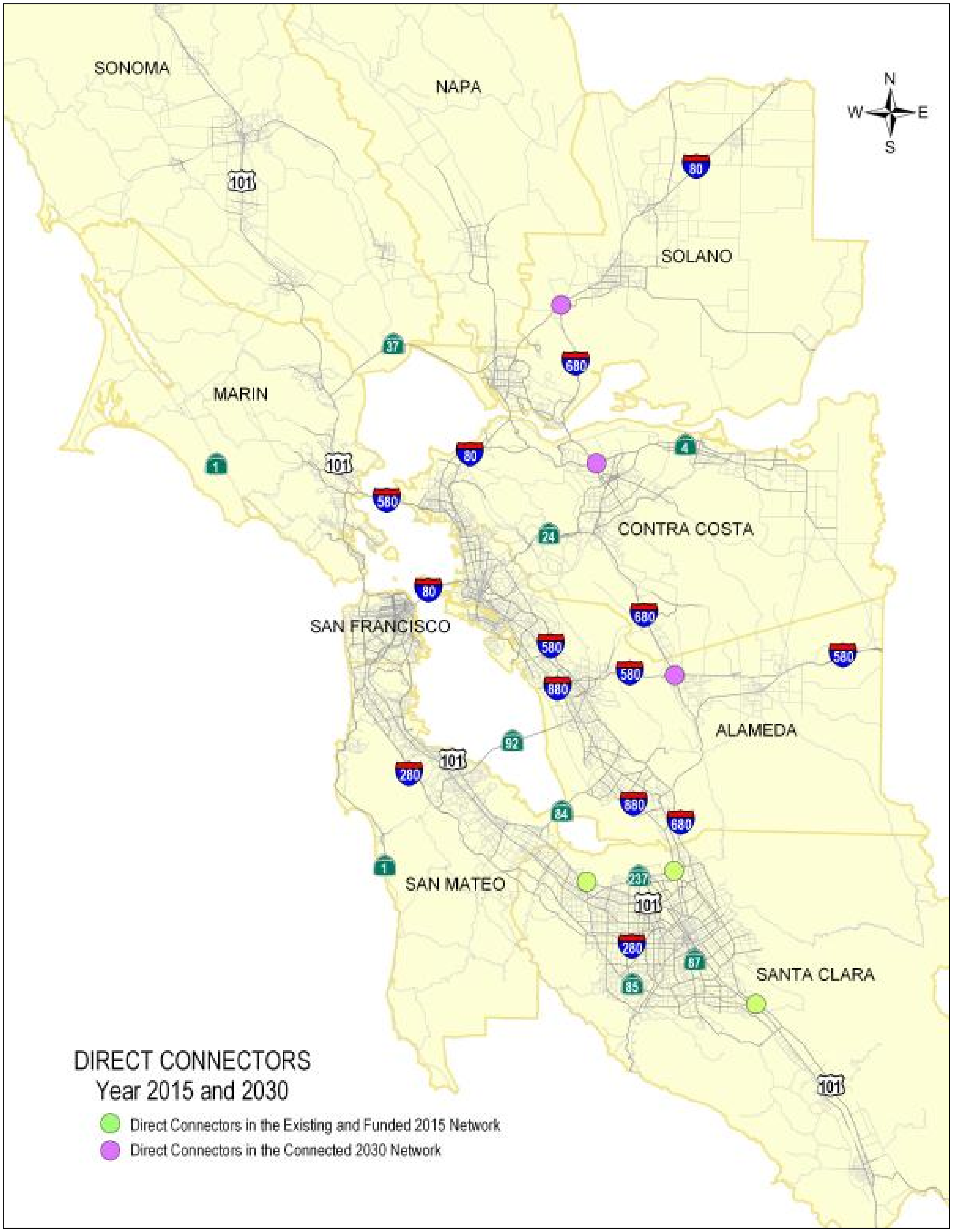
HOV/HOT Lane Extensions in the Existing and Funded 2015 Network	HOV/HOT Lane Extensions in the Connected 2030 Network
US 101 from SR 12 to Windsor River Road in Sonoma County	I-80 from Air Base Parkway in Solano County to Yolo County line
	I-580 eastbound from Greenville Road in Alameda County to San Joaquin County line I-580 westbound from I-680 to San Joaquin County line
	US 101 from Cochrane to SR 25 in Santa Clara County
	US 101 from Whipple to Millbrae Avenue in San Mateo County
	I-880 from Hacienda Avenue (northbound) and Marina Boulevard (southbound) to 98th Avenue in Oakland

Figure 1.8-1: HOT Lane Gap Closures and Extensions



Source: Caltrans and MTC, 2006

Figure 1.8-2: Direct Connectors



Source: Caltrans and MTC, 2006

1.8.2 Existing Express Bus Services

The purpose of this section is to briefly assess the opportunities and benefits for express busses in conjunction with the HOT lanes network. A number of sources were used to prepare this section:

- MTC's Regional Transportation Plan (RTP), *Transportation 2030* which details transportation investments throughout the nine-county San Francisco Bay Area from 2005 through 2030
- 2004 Regional Express Bus (REB) planning documents
- 2002 High Occupancy Vehicle (HOV) Lane Master Plan Update
- 511 Website and associated transit links

1.8.2.1 Existing Express Bus Service

Various express bus services exist today in the San Francisco Bay Area. For the purposes of this section, "express bus" is defined as a bus transit service (not rail or ferry) that either crosses one of the Bay Area toll bridges or operates between counties on a limited stop or subscription basis. Among them are:

- Golden Gate Transit connecting the north bay counties to San Francisco via US 101 with a number of express services
- WestCAT provides three express routes to the El Cerrito Del Norte BART station from western Contra Costa County, as well as one express service from Hercules to downtown San Francisco
- San Joaquin RTD Commuter services from the San Joaquin Valley to Livermore/Pleasanton, Santa Clara and southern San Mateo Counties via I-580, I-680 and SR 237/SR 84 and I-880
- AC Transit Transbay services via the Bay Bridge
- Dumbarton Express provides transbay services via the Dumbarton Bridge
- SamTrans provides various express bus services into San Francisco using a combination of roadways
- VTA in operates two express bus lines that provide service to Fremont BART as well as express bus service over SR 17 to Santa Cruz (operated in conjunction with Santa Cruz Metro)

Opportunities

The HOT lanes networks under study could benefit express buses by offering more reliable travel times and operating speeds. Furthermore, a HOT lanes network potentially could be designed to include direct ingress/egress ramps, direct HOT connectors, and on-line stations where feasible. It is assumed that express buses would be exempt from tolls on HOT lanes.

The *2002 High-Occupancy-Vehicle (HOV) Lane Master Plan Update* identified nine (9) express bus long-distance routes or "streams" for the Bay Area to work towards providing. The nine routes or "streams" identified are listed in the table below along with how those routes would be served by the 2015 and 2030 HOV/HOT networks considered in this study.

Questions to be Addressed

Several questions should be addressed in subsequent planning stages:

- Do these future routes still reflect the existing and/or future major commute travel patterns by connecting the major housing and employment centers?
- Do these routes mirror and thus compete with other existing, new or proposed long-distance transit options such as rail, BART or ferry?
- Are these routes consistent with other HOV lane infrastructure planned or proposed such as freeway-to-freeway connections and/or direct access ramps?

Table 1.8-4: Express Bus Routes

Express Bus Long Distance Routes identified in 2002 MTC HOV Master Plan Update	Relation to 2015 Existing and Funded Network	Relation to 2030 Connected Network
Marin County to Berkeley/Oakland via I-580 and I-80	Moderately-served as no HOV/HOT lane is planned for the segment of US101 from the Golden Gate Bridge north past the Waldo Tunnel	Moderately-served as no HOV/HOT lane is planned for the segment of US101 from the Golden Gate Bridge north past the Waldo Tunnel
Sonoma County to downtown San Francisco via US101	Moderately-served as no HOV/HOT lanes are planned for the Novato Narrows and Waldo Tunnel segments on US 101	Well-served except for the segment from the Golden Gate Bridge north past the Waldo Tunnel on US 101
Solano County to downtown San Francisco via I-80	Moderately-served in segments on I-80; segment from I-680 to the Carquinez Bridge does not include HOV/HOT lanes	Well-served for entire length of I-80 up to the Bay Bridge
Solano and western Contra Costa Counties to Santa Clara County via I-680	Moderately-served as segments from I-80 to the Benicia-Martinez Bridge, segment at Walnut Creek and segment from Contra Costa/Alameda County line to Niles Canyon Road are not planned to have HOV/HOT lanes by 2015	Well-served with full I-680 corridor from Solano County to Santa Clara County provided
Eastern Contra Costa County and Livermore/San Ramon Valleys to Santa Clara County via I-580, I-680, I-880, SR 84, SR 237 and US 101	Moderately-served as various segments on I-680, I-580, SR 84 and SR 237 do not have HOV/HOT lanes planned to exist by 2015	Well-served with all segments provided except for the SR 84 crossing of the Bay
Livermore/San Ramon Valleys to Berkeley/Emeryville via I-580 & I-680 and SR24	Poorly-served as segments on I-580 and SR 24 are not planned to have HOV/HOT lanes by 2015	Slightly improved (but still poor) with I-580/I-680 freeway-to-freeway connection; segments on I-580 and SR 24 do not have planned HOV/HOT lanes by 2030
Livermore/San Ramon Valleys to San Mateo County via I-580, I-880 and SR92;	Poorly-served as segments on I-580 and SR 92 are not planned to have HOV/HOT lanes by 2015	Poorly-served as segments on I-580 and SR 92 are not planned to have HOV/HOT lanes by 2030
Hayward/Oakland to downtown San Francisco via I-880 and I-80 (Bay Bridge)	Poorly-served as HOV/HOT lanes are not planned for I-880 or I-80 (Bay Bridge) by 2015	Moderately-served as HOV/HOT lanes are not planned for I-80 (Bay Bridge)
Southern Santa Clara County to downtown San Francisco via US 101 and SR85	Moderately-served as lanes exist from south Santa Clara County to San Carlos on US 101	Well-served with lanes from south Santa Clara county to approximately the US 101/I-280 connection in San Francisco

Benefits

The benefits associated with express bus are generally related to reducing commute traffic – air quality, congestion reduction, fuel savings, societal costs for accidents and policing. The following table (table 1.8-5) presents a simplified assessment of the potential commute traffic benefits of express bus services that might be achieved at select operating levels of service and based on the assumptions noted. A regional HOT lanes network could enhance the benefits offered by express buses by improving bus travel times and reliability. Further, HOT lane toll revenue remaining after covering operations and maintenance expenses could be used to expand or enhance regional express bus services. This would have additional benefits of improving travelers' choices and channeling some of the benefits from HOT lanes investments to bus riders, possibly addressing concerns about modal and income equity outlined in the Task 4 report for this study.

Table 1.8-5: Estimated Passenger Cars Removed at Various Express Bus Headways

Express Bus Headways	Passenger-Car Equivalents per Hour -Added to HOT Lanes (at 2 cars per bus)	Number of Express Bus Users (at 50 seats per vehicle and 85% utilization)	Passenger car Equivalents Removed from General Purpose and HOV Lanes (at 1.2 average peak period auto occupancy)	Net Passenger Car Removed from System
5	24	510	425	292
10	12	255	213	201
15	8	170	142	134
20	6	128	107	101
30	4	85	71	67
60	2	43	36	34

At the headways considered in the preceding table, the number of buses operating in an HOV/HOT lane generally would be a small share of the total lane capacity, assumed to be 1,600 vehicles per hour (see Section 1.4). At an express bus headway of 5 minutes, 12 buses per hour would operate in an HOV/HOT lane. That would equate to about 24 passenger car equivalents or about 1.5% to 3% of the lane volume. Thus, even very frequent bus service would not appear to have an undue impact on reliability of the HOV/HOT lane.

1.9 DEMAND AND REVENUE FORECASTS COMPARED WITH COSTS

A comparison of the HOT lane revenue and cost estimates developed in this study suggests that revenues would be sufficient to cover costs in several corridors. Further, the concept of a regional HOT lanes network appears to be feasible in so far as total revenue from the Existing and Funded Network exceeds costs and is sufficient to cover a substantial portion of the cost to expand to the Connected Network.

Two measures are used to compare revenues and costs. The first is the ratio of annual revenue to cost, where cost is expressed as the amortized capital cost plus one year of operating and maintenance cost. (Similar to a "coverage ratio"). A ratio greater than 1.0 indicates revenues are greater than costs. The second is net revenue. In order to be conservative, net revenue has been computed based on both a low revenue estimate and a high revenue estimate. The high revenue estimate is the value generated by the toll optimization model. The low estimate represents 80 percent of the high estimate; this is intended to reflect simplifications made in the forecasting to date. It is also worth noting that the HOT lane cost estimates were developed to be conservative meaning that refined cost estimates may well be less than those used here.

The strongest corridors are those with both a high ratio of revenues to amortized costs and a large amount of net revenue (a corridor that has a revenue to amortized cost ratio of five to one but only generates $5 million more than it costs may not be as valuable as one that has a revenue to amortized coverage ratio of two but generates $200 million in net revenue). Findings pertaining to the overall networks and to the several corridors are reviewed below.

When comparing costs and revenues, it is important to restate the revenue estimates should be considered a first approximation. This is because this large-scale evaluation is based on one forecast of the MTC travel model and the tolling model but does not reflect feedback between the two models to reflect changes in travel patterns which might occur as a result of the toll itself, a redistribution of trips from general purpose to HOT lanes and/or possibly a redistribution among and between facilities sub-regionally. The results do provide a good order of magnitude for assessing both regional feasibility and determining the corridors likely to be the most successful in terms of revenue generation in the near-term.

1.9.1 Existing and Funded Network

Revenues based on HOT lane demand for this network are compared with costs in tables 1.9-1, 1.9-2, and 1.9-3. In all of these tables, the net revenue calculation represents the difference between the present value of 30 years of revenues and costs, assuming a 4% discount rate. Table 1.9-1 presents the revenue and cost comparisons for the Existing and Funded Network at current HOV occupancy requirements. Table 1.9-2 presents the revenue and cost comparisons for the same network but with the HOV occupancy requirement in two corridors increased from 2+ to 3+ (i.e., only carpools with 3 or more persons would travel free of charge) because the HOV lanes in those corridors are expected to become significantly congested by year 2020. For illustrative purposes, Table 1.9-3 presents compares revenues and costs for the network, assuming the HOV occupancy requirement is 3+ in all corridors. This illustrates the potential revenue implications of an overall higher HOV requirement, though no such general increase is proposed.

Under all three scenarios, several corridors have ratios of revenues to amortized cost that are significantly greater than 1.0, meaning that it appears that these corridors will be able to generate sufficient revenues to cover their HOT lane capital cost as well as operations costs. In addition, some corridors' revenue to amortized cost ratios appear better in later years. In these cases, growth in corridor travel causes HOT lane travel time advantages to improve over time and revenue increases accordingly.

In addition, the Existing and Funded Network as a whole is projected to generate a significant amount of net revenue under any of the three scenarios. However, some corridors are not projected to generate enough revenue to cover cost under current HOV occupancy requirements, even though future forecasts suggest the lane will not become crowded enough to warrant increasing the occupancy requirement.

Observations are listed below about estimated net revenues for the corridors at current HOV requirements as shown in Table 1.9-1. In this scenario 2-person carpools are allowed to use HOT lanes free of charge in all corridors except those where the current HOV occupancy requirement is 3-persons (I-80 in Alameda and Contra Costa County and the I-880 approach to the Bay Bridge).

- Combined, all Existing and Funded Network corridors are forecasted to generate between $2.2 and $3.2 billion in net revenues over the 30-year period *with Current HOV Occupancy Requirement(s)*.
- Five corridors generate substantial net revenues over the 30-year period. The five corridors with highest net revenues (at least $250 million at the low end) are:
  - SR 85 SC
  - I-880 ALA-SC
  - I-680 ALA-SC
  - US 101 SM-SC
  - I-80 ALA-CC
  - Most other corridors appear to break more or less even over the 30-year period, with net revenues ranging from $0 to $85 million over 30 years or resulting in a net cost of $5 million to $40 million. Two exceptions are I-580 and US 101 in Marin and Sonoma counties.
    - In the Existing and Funded Network, I-580 has a HOT lane in the eastbound direction only (by comparison, almost all other corridors have HOT lanes in both directions). Net revenue from the eastbound I-580 HOT lane is estimated to be $70 to $100 million over 30 years, if 2-person carpools are permitted to travel free of charge. And,
    - In the Existing and Funded Network, net revenue for US 101 in Marin and Sonoma is estimated fall short of costs by approximately $150 million over thirty years.

Table 1.9-1: Existing and Funded Network at Current HOV Occupancy Requirement: Cost Ratio and Net Revenue Over 30 Year Period – Rank Ordered by 2015 Revenue/Cost Ratio

	Revenue/Cost Ratio at Current HOV Requirements (Greater than 1.0 means revenues exceed costs)			30 Years of Revenue Minus Costs in Net Present Value ($s in Millions and Rounded to Nearest $5 Million)	
Corridor	**Carpool Policy**	**2015**	**2030**	**Low Range**	**High Range**
SR 85 SC	2+	7.3	4.0	$250	$350
I-880 ALA-SC	2+	5.3	6.4	$365	$500
I-680 ALA-SC	2+	4.7	13.8	$575	$745
US 101 SM-SC	2+	4.0	7.1	$515	$705
I-80 ALA-CC	3+	2.3	8.2	$670	$880
I-680 CC	2+	1.5	1.9	$5	$40
SR 87 SC	2+	1.0	2.4	$15	$30
SR 92 ALA WB (San Mateo Bridge approach)	2+	1.1	1.4	$(5)	$0
SR 84 ALA WB (Dumbarton Bridge approach)	2+	1.0	0.6	$(10)	$(5)
SR 237 SC	2+	0.9	3.3	$55	$85
I-280 SC	2+	0.7	1.4	$(20)	$(10)
I-80 SOL	2+	0.3	1.6	$(5)	$5
SR 4 CC	2+	0.3	0.7	$(50)	$(40)
I-580 ALA EB only	2+	0.2	4.0	$70	$100
US 101 MAR-SON	2+	0.2	0.4	$(155)	$(145)
I-880 ALA NB (Bay Bridge approach)	3+	0.1	0.2	$(10)	$(5)
Total Revenue less Costs – Approximate				**$2,265**	**$3,235**

Notes: 1. Assumes 4% real discount rate.

2. Revenue estimates for SR 85 and SR 87 pivot off estimates generated in VTA 2005 study.

Observations are listed below about estimated net revenues when the HOV occupancy requirement is increased in selected corridors that would otherwise become crowded with carpools by 2020. (See Table 1.9-2.) In this scenario, the HOV occupancy requirement has been increased to 3-persons in I-680 in Contra Costa County and in I-580. (See Section 1.5 for a discussion of corridors in which HOV lanes are projected to become crowded.)

- Combined, all Existing and Funded Network corridors are forecasted to generate between $2.9 and $4.1 billion in net revenues over the 30-year period *with an Increased HOV Occupancy Requirement* in two corridors – I-680 Contra Costa and I-580 (eastbound only) in Alameda County.
  - With an increased HOV occupancy from 2+ to 3+, I-680 is forecasted to increase net revenues over the 30-year period from a range of $5-40 million to a range of $600-790 million; reflecting an increase of $650 million in *net* revenue on average.
  - With an increased HOV occupancy from 2+ to 3+, I-580 eastbound only is forecasted to increase net revenues over the 30-year period from a range of $70-100 million to a range of $170-220 million; reflecting an increase of $125 million in *net* revenue on average.

- This places both corridors, which rated somewhere in the middle under current (2+) HOV occupancy requirements, among the strongest generators of net revenue and gives them very high revenue to cost ratios with 3+ occupancy requirements.

Table 1.9-2: Existing and Funded Network with Increased HOV Occupancy Requirements in Selected Corridors: Cost Ratio and Net Revenue Over 30 Year Period – Rank Ordered by 2015 Revenue/Cost Ratio

	Revenue/Cost Ratio With Selected Increased HOV Requirements (Greater than 1.0 means revenues exceed costs)			30 Years of Revenue Minus Costs in Net Present Value ($s in Millions and Rounded to Nearest $5 Million)	
Corridor	**Carpool Policy**	**2015**	**2030**	**Low Range**	**High Range**
SR 85 SC	2+	7.3	4.0	$250	$350
I-680 CC	3+	5.4	10.2	$600	$790
I-880 ALA-SC	2+	5.3	6.4	$365	$500
I-680 ALA-SC	2+	4.7	13.8	$575	$745
US 101 SM-SC	2+	4.0	7.1	$515	$705
I-80 ALA-CC	3+	2.3	8.2	$670	$880
SR 87 SC	2+	1.0	2.4	$15	$30
SR 92 ALA WB (San Mateo Bridge approach)	2+	1.1	1.4	$(5)	$0
SR 84 ALA WB (Dumbarton Bridge approach)	2+	1.0	0.6	$(10)	$(5)
SR 237 SC	2+	0.9	3.3	$55	$85
I-280 SC	2+	0.7	1.4	$(20)	$(10)
I-580 ALA EB only	3+	0.5	8.1	$170	$220
I-80 SOL	2+	0.3	1.6	$(5)	$5
SR 4 CC	2+	0.3	0.7	$(50)	$(40)
US 101 MAR-SON	2+	0.2	0.4	$(155)	$(145)
I-880 ALA NB (Bay Bridge approach)	3+	0.1	0.2	$(10)	$(5)
Total Revenue less Costs – Approximate				**$2,960**	**$4,105**

Notes: 1. Shaded cells represent changes from the "Current HOV requirement" and are the only corridors with differences from the Current HOV alternative's revenue estimates

2. Assumes 4% real discount rate.

3. Revenue estimates for SR 85 and SR 87 pivot off estimates generated in VTA 2005 study.

For illustrative purposes, Table 1.9-3 presents a comparison of costs and revenues assuming all corridors operate with a 3+ HOV occupancy requirement (i.e., carpools travel toll-free only if they have 3 or more occupants). Observations include the following:

- The overall estimate of net revenues for the system is $4.5 to $ 5.9 billion (an increase of $2.2 to $2.6 billion over the *current HOV requirement* results presented in Table 1.9-1 and an increase of $1.5 to $1.8 billion over the *increased HOV requirement* results presented in Table 1-9.2) if all corridors operated at a 3+ HOV level.

By 2030, nearly all corridors are estimated to have a positive revenue to cost ratio (more revenues than costs).

Table 1.9-3: Existing & Funded Network Assuming 3+ HOV Occupancy Requirement in All Corridors: Cost Ratio and Net Revenue – Rank Ordered by 2015 Revenue/Cost Ratio

	Revenue/Cost Ratio With 3+ HOV Requirements in all Corridors (Greater than 1.0 means revenues exceed costs)			30 Years of Revenue Minus Costs in Net Present Value ($s in Millions and Rounded to Nearest $5 Million)	
Corridor	**Carpool Policy**	**2015**	**2030**	**Low Range**	**High Range**
I-880 ALA-SC	3+	16.2	36.5	$2,675	$3,380
US 101 SM-SC	3+	9.7	35.7	$475	$655
I-680 ALA-SC	3+	9.4	51.6	$215	$295
I-680 CC	3+	5.4	10.2	$0	$15
SR 84 ALA	3+	3.4	6.3	$35	$45
SR 92 ALA	3+	2.8	5.8	$20	$25
I-80 ALA-CC	3+	2.3	8.2	$435	$585
SR 237 SC	3+	1.7	10.8	$325	$425
I-280 SC	3+	1.2	2.7	$25	$50
I-80 SOL	3+	0.9	4.3	$65	$90
SR 4 CC	3+	0.8	2.3	$25	$55
I-580 ALA	3+	0.5	8.1	$170	$220
US 101 MAR-SON	3+	0.4	1.8	$10	$30
I-880 SFOBB	3+	0.1	0.2	$0	$(10)
SR 85 SC	3+	n/a	n/a	n/a	n/a
SR 87 SC	3+	n/a	n/a	n/a	n/a
Total Revenue less Costs – Approximate				**$4,475**	**$5,860**

Notes: 1. Assumes 4% real discount rate.

2. Revenues assuming 3+ HOV occupancy requirement not available for SR 85 and SR 87 because revenue estimates pivot off VTA study.

In summary, the corridors with the greatest potential to cover their capital, operating and maintenance, and centralized system costs and to generate significant net revenue are listed below and shown in Figure 1.9-1:

- I-80 Alameda-Contra Costa
- I-680 Alameda-Santa Clara
- US 101 San Mateo-Santa Clara
- I-880 Alameda-Santa Clara
- SR 85 Santa Clara

Corridors whose potential appears to improve by 2030 (and are not on the preceding list) are:

- I-680 Contra Costa (and it would be stronger at a 3+ HOV requirement)
- I-580 Alameda (eastbound direction only was included in this network, and it, too, would be stronger at a 3+ HOV requirement)

1.9.2 Connected Network

The analysis of the Connected Network differs from that for the Existing and Funded network in three respects.

- First, revenue has been forecast for one future year only, 2030 (rather than two future years, 2015 and 2030, as for the Existing and Funded Network).
- Second, a 30-year estimate of revenue is not available for the Connected Network because post-2030 travel forecasts were not available. The revenue estimates are for one-year (Year 2030).
- Third, capital costs for corridors added after 2015 (i.e., added to those corridors not in the Existing and Funded Network) include both the construction of the high occupancy vehicle lane(s) associated with the added corridors or segments, as well as the cost of tolling them for HOT usage. At $11.9 million per lane mile on average[6], the construction costs per mile are estimated to be significantly higher for the Connected Network segments than for the segments considered in the Existing and Funded Network (which were $2.4 million per mile on average).

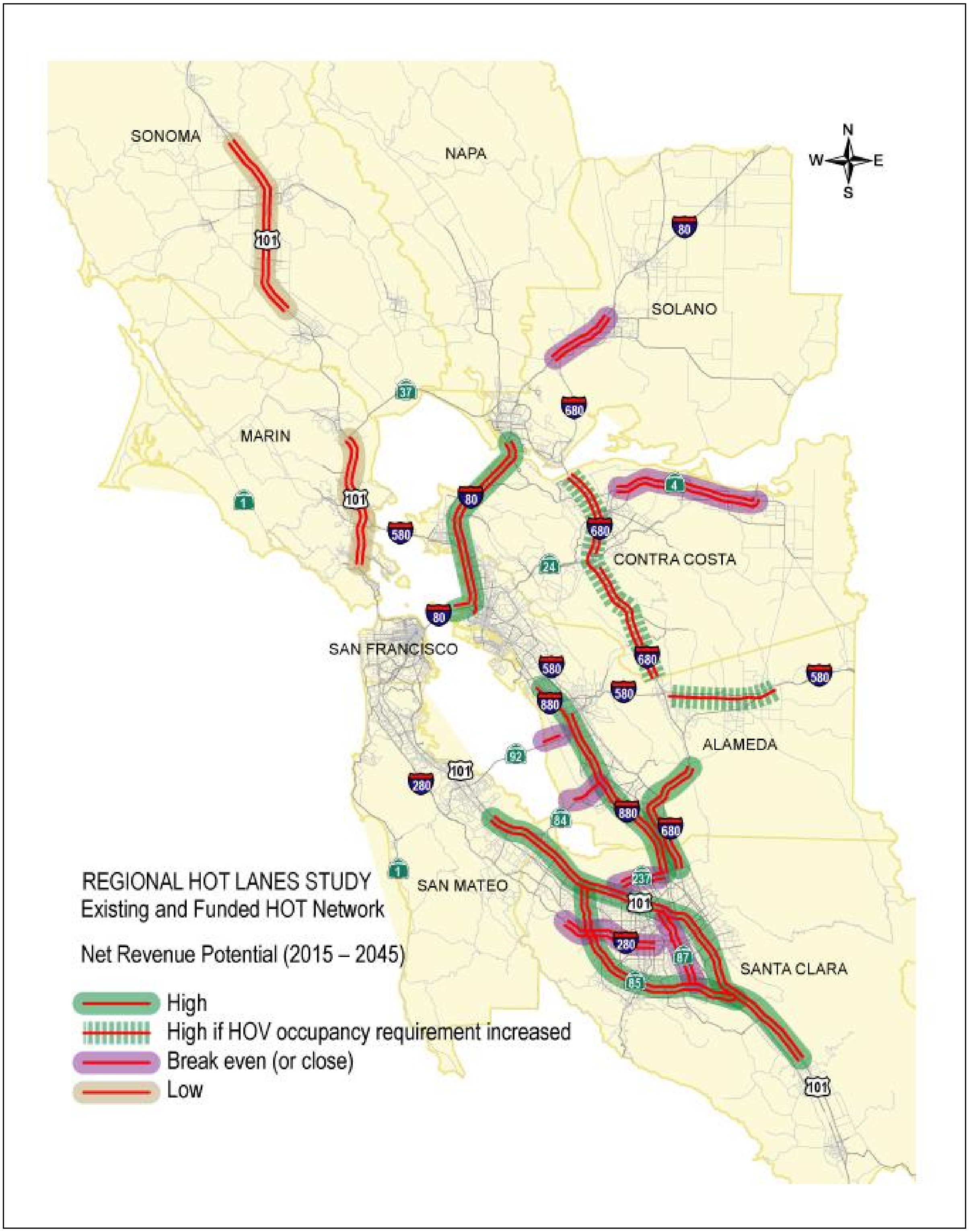
Tables 1.9-4, 1.9-5, and 1.9-6 present the revenue to cost ratios and the net revenue for corridors in the Connected Network. The difference between each table is the HOV Requirement that has been tested: Table 1.9-4 presents the results of the Connected Network using the *Current HOV Requirement*; Table 1.9-5 presents the results of the Connected Network using an *Increased HOV Requirement in Selected Corridors*; and Table 1.9-6 applies *3+HOV Requirement in All Corridors* -- as with the Existing and Funded Network, this is presented for illustrative purposes. In each of these tables, the net revenue calculation represents the difference between year 2030 revenues and the amortized cost plus one year of operating and maintenance cost.

Observations listed below are based on Table 1.9-4, which presents net revenues for the Connected Network with all corridors at the *Current HOV Occupancy Requirement*.

- In total, the Connected Network is estimated to produce a one-year annual revenue in the year 2030 that is estimated to range from $20 million less than the estimated total cost to $60 million more than the total cost.
- Twelve (12) of the 19 corridors show break-even or higher revenues than costs at the low end of the revenue range.

[6] Note: The estimated costs for the HOT lane improvements and/or conversions range from an estimated $8 Million per mile in segments that are less complex to implement (and may not have a project study report – PSR available) to over $17 Million in segments that are complex and/or require direct connections to implement.

Figure 1.9-1: 30-Year Net Revenue Potential for the Existing and Funded Network



Source: ECONorthwest, 2006

Table 1.9-4: Connected Network at Current HOV Requirement: Revenue/Cost Ratio and 2030 (One-Year) Net Revenue – Rank Ordered by 2030 Revenue/Cost Ratio

	Revenue/Cost Ratio at Current HOV Requirements (Greater than 1.0 means revenues exceed costs)		2030 Annual Revenue Minus Amortized Annual Costs ($s in Millions)	
Corridor	**Carpool Policy**	**2030 Revenue/Cost Ratio**	**Low Range**	**High Range**
SR 85 SC	2+	4.7	$ 20	$ 27
I-880 ALA-SC	2+	3.3	$ 27	$ 38
I-680 ALA-SC	2+	2.7	$ 21	$ 31
US 101 SM-SC	2+	2.7	$ 33	$ 49
SR 87 SC	2+	1.9	$ 2	$ 3
I-80 ALA-CC	3+	1.9	$ 7	$ 12
I-80 SOL (east of Vallejo)	2+	1.6	$ 11	$ 24
SR 92 ALA WB (San Mateo Bridge approach)	2+	1.4	$ 0	$ 0
SR 237 SC	2+	1.3	$ 1	$ 3
I-680 CC	2+	1.3	$ 0	$ 4
I-280 SC	2+	1.2	$ (0)	$ 2
US 101 SM	2+	0.7	$ (12)	$ (9)
I-80 SOL (through Vallejo)	3+	0.4	$ (5)	$ (4)
I-580 ALA	2+	0.3	$ (32)	$ (29)
US 101 MAR-SON	2+	0.2	$ (53)	$ (51)
SR 4 CC	2+	0.1	$ (18)	$ (17)
I-680 SOL	2+	0.1	$ (16)	$ (16)
I-880 NB Bay Bridge approach	3+	0.1	$ (0)	$ (0)
SR 84 ALA WB Dumbarton Bridge approach	2+	0.1	$ (6)	$ (6)
Total Revenue less Costs – Approximate			**$ (20)**	**$ 60**

Note: Revenue estimates for SR 85 and SR 87 pivot off estimates generated in VTA 2005 study

Observations listed below are based on Table 1.9-5, which includes estimated net revenues for the Connected Network with HOV occupancy requirements increased in four corridors that would otherwise become crowded with carpools by 2030. In this scenario, the HOV occupancy requirement has been increased to 3-persons in I-680 in Contra Costa County, I-580, I-880 and US 101 in Marin and Sonoma counties (see Section 1.5 for a discussion of corridors in which HOV lanes are projected to become crowded).

Table 1.9-5: Connected Network with HOV Occupancy Requirements Increased to 3+ in Selected Corridors: Cost Ratio and 2030 Net Revenue – Rank Ordered by 2030 Revenue/Cost Ratio

	Revenue/Cost Ratio With Selected Increased HOV Requirements (Greater than 1.0 means revenues exceed costs)		2030 Annual Revenue Minus Amortized Annual Costs ($s in Millions)	
Corridor	**Carpool Policy**	**2030 Revenue/Cost Ratio**	**Low Range**	**High Range**
I-880 ALA-SC	3+	12.7	$ 156	$ 200
I-680 CC	3+	7.4	$ 71	$ 92
SR 85 SC	2+	4.7	$ 20	$ 27
I-680 ALA-SC	2+	2.7	$ 21	$ 31
US 101 SM-SC	2+	2.7	$ 33	$ 49
SR 87 SC	2+	1.9	$ 2	$ 3
I-80 ALA-CC	3+	1.9	$ 7	$ 12
I-580 ALA	3+	1.7	$ 16	$ 31
I-80 SOL (east of Vallejo)	2+	1.6	$ 11	$ 24
SR 92 ALA WB (San Mateo Bridge approach)	2+	1.4	$ 0	$ 0
SR 237 SC	2+	1.3	$ 1	$ 3
I-280 SC	2+	1.2	$ (0)	$ 2
US 101 MAR-SON	3+	0.7	$ (25)	$ (16)
US 101 SM	2+	0.7	$ (12)	$ (9)
I-80 SOL (through Vallejo)	3+	0.4	$ (5)	$ (4)
SR 4 CC	2+	0.1	$ (18)	$ (17)
I-680 SOL	2+	0.1	$ (16)	$ (16)
I-880 NB Bay Bridge approach	3+	0.1	$ (0)	$ (0)
SR 84 ALA WB Dumbarton Bridge approach	2+	0.1	$ (6)	$ (6)
Total Revenue less Costs – Approximate			**$ 256**	**$ 405**

Notes: 1. Shaded cells represent changes from the "Current HOV requirement" and are the only corridors with differences from the Current HOV alternative's revenue estimates.

2. Revenue estimates for SR 85 and SR 87 pivot off estimates generated in VTA 2005 study.

- With increased HOV occupancy levels in these four corridors, the Connected Network is estimated to generate between $256 and $405 million more than the annual costs in year 2030. This represents a significant opportunity to help fund development of the Connected Network.
- Thirteen (13) of the 19 corridors show break-even or higher revenues than costs at the low end of the revenue range.

- The US101 (Marin-Sonoma) corridor improves its' revenue/cost ratio with the 3+ HOV Occupancy Requirement, but still has a Revenue/Cost ratio of less than 1.0 and is forecasted to cost $16 to $25 million more than projected revenues in the year 2030.

Table 1.9-6 illustrates the revenue/cost ratios with 3+ HOV occupancy for 2030 with the Connected Network. Observations from this table are presented on the following page.

Table 1.9-6: Connected Network Assuming 3+ HOV Occupancy Requirement in All Corridors: Cost Ratio and 2030 Net Revenue – Rank Ordered by 2030 Revenue/Cost Ratio

	Revenue/Cost Ratio With 3+ HOV Requirements in all Corridors (Greater than 1.0 means revenues exceed costs)		2030 Annual Revenue Minus Amortized Annual Costs ($ in Millions)	
Corridor	**Carpool Policy**	**2030 Revenue/Cost Ratio**	**Low Range**	**High Range**
I-680 ALA-SC	3+	17.0	$ 225	$ 285
US 101 SM-SC	3+	15.1	$ 327	$ 416
I-880 ALA-SC	3+	12.7	$ 156	$ 200
I-680 CC	3+	7.4	$ 71	$ 92
SR 92 ALA WB (San Mateo Bridge approach)	3+	6.3	$ 2	$ 3
I-280 SC	3+	5.6	$ 27	$ 35
SR 237 SC	3+	4.3	$ 22	$ 30
I-80 SOL (east of Vallejo)	3+	3.5	$ 72	$ 100
US 101 SM	3+	2.0	$ 16	$ 27
I-80 ALA-CC	3+	1.9	$ 7	$ 12
I-580 ALA	3+	1.7	$ 16	$ 31
SR 84 ALA WB Dumbarton Bridge approach	3+	1.0	$ (1)	$ (0)
US 101 MAR-SON	3+	0.7	$ (25)	$ (16)
SR 4 CC	3+	0.4	$ (13)	$ (11)
I-80 SOL (through Vallejo)	3+	0.4	$ (5)	$ (4)
I-680 SOL	3+	0.2	$ (15)	$ (14)
I-880 NB Bay Bridge approach	3+	0.1	$ (0)	$ (0)
SR 85 SC	n/a	n/a	n/a	n/a
SR 87 SC	n/a	n/a	n/a	n/a
Total Revenue less Costs – Approximate			**$ 882**	**$ 1,186**

Revenues assuming 3+ HOV occupancy requirement not available for SR 85 and SR 87 because revenue estimates pivot off VTA study

Observations listed below are based on Table 1.9-6, which includes estimated net revenues for the Connected Network with all corridors at a 3+ HOV occupancy requirement.

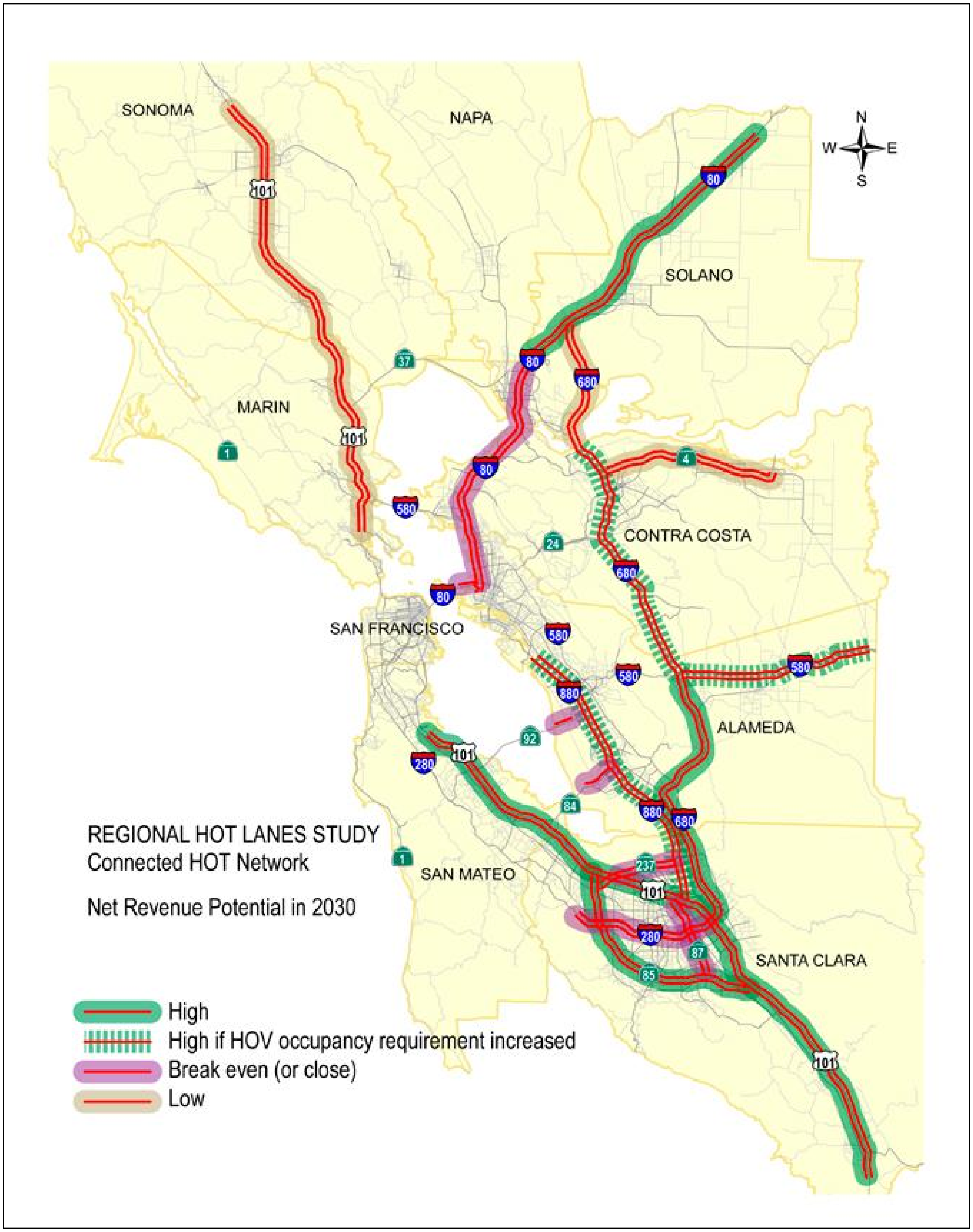
- With a region-wide 3+ HOV occupancy requirement, the Connected Network is estimated to produce between $0.9 to $1.2 billion in net revenues in year 2030.
- It should be noted that SR 85 and SR 87 are not included in Table 1.9-6 as these corridors remain 2+. If the revenues were included at the 2+ threshold for these corridors, the overall region-wide revenue would increase by $22 to 425 million in the year 2030.
- While a region-wide standard of 3+ HOV occupancy is not recommended, this review does demonstrate the revenue potential in the event that HOV volumes grow to the point that it is necessary to consider increasing HOV occupancy in all corridors.

In summary, several corridors have high ratios of revenue to cost ratios (four exceed 10:1 at today's HOV occupancy requirements) as well as significant net revenue estimates. Noting that the costs of as-yet-unfunded HOV lanes are included for these corridors, the annual net revenue amounts are quite significant. A significant 2030 net revenue amount should not be taken to mean that the same amount can be realized each year thereafter. Changes in HOV usage will affect both the toll rates and the gross toll revenues over time.

The Connected Network corridors with the greatest potential to cover their capital, operating and maintenance, and centralized system costs as of 2030 as well as to generate significant revenue over and above their costs) are listed below and shown in Figure 1.9-2.

- I-880 – Alameda and Santa Clara (extension of HOV and HOT lane considered in the Existing and Funded Network) and it would have higher revenue potential at a 3+ HOV occupancy requirement
- I-680 – Contra Costa (extension of HOV and HOT lane considered in the Existing and Funded Network) and it would have higher revenue potential at a 3+ HOV occupancy requirement
- SR 85 Santa Clara (no change from HOV/HOT lane in the Existing and Funded Network)
- I-680 – Alameda-Santa Clara – (extension of HOV and HOT lane considered in the Existing and Funded Network) and it would have higher revenue potential at a 3+ HOV occupancy requirement
- US 101 – San Mateo and Santa Clara (extension of HOV and HOT lane considered in the Existing and Funded Network) and it would have a slightly higher revenue potential at a 3+ HOV occupancy requirement

Figure 1.9-2: Year 2030 Net Revenue Potential for the Connected Network



Source: ECONorthwest, 2006

1.10 SUMMARY OF FINDINGS APPLICABLE TO FUTURE WORK- REGION-WIDE NETWORK ANALYSIS: DEMAND, COSTS AND REVENUE

The HOT lane evaluation presented here demonstrates that HOT lanes in several corridors can generate sufficient revenues to cover their capital and operations costs and can improve traffic flow in the Bay Area. Due to some vehicles shifting from general purpose lanes to HOT lanes, travel speeds in the general purpose lanes can improve in most corridors, at least on a near term basis, but some of this may be offset by growth in general travel and shifting of trips from the shoulder times to the peak. Although travel speeds in the HOV/HOT lanes will decline somewhat from today's level as those lanes become more heavily utilized, the HOT lane can be priced so that toll paying vehicles do not unduly degrade travel speeds. In fact, current California law requires that HOT lanes maintain level of service C.

Capital costs considered to date allow for developing HOT lanes while meeting appropriate state and federal design standards for HOV lanes and emerging design principles for HOT lanes in California. Design refinements during project development may reduce the capital costs below the levels estimated through to date.

Operating and maintenance costs, as well as centralized system costs, should be within the ranges estimated to date; however, note that pavement maintenance and rehabilitation costs are not included in estimates to date and are assumed to be covered otherwise. This assumption may need to be reviewed in future study phases.

Perhaps as significant as the findings concerning individual corridors is the system level costing and revenue estimation. It appears likely that HOT lane revenues are sufficient to cover costs and may be sufficient to advance expansion of the HOV/HOT network (see Table 1.10-1). It is estimated that if all the HOT lanes considered in the Existing and Funded Network were developed and operational over a thirty year period, the region could gain up to $3 billion in net revenue over and above the cost of implementation and operation (with some corridors considered at higher vehicle occupancies, this potential net revenue could be higher). When it becomes appropriate, raising the HOV occupancy requirement in three corridors from 2+ to 3+ could cause the regional total net revenue to grow to a range of $3 to $4 billion. These are significant amounts, given that they would come from within the region and be in addition to other federal, state, and local funding.

Table 1.10-1: Existing and Funded HOT Lanes Network, Net Revenue Over 30 Years (2015 to 2045)*

	Existing HOV Occupancy Requirements**	Increased HOV Occupancy Requirements in Selected Corridors***
Revenues over 30 Years	$3.8 to $4.7 billion	$4.4 to $5.6 billion
Costs over 30 Years	$1.5 billion	$1.5 billion
Net Revenue over 30 Years	$2.3 to $3.2 billion	$3.0 to $4.1 billion

* Present discounted value of costs and revenues assuming 4% real discount rate.

** Vehicles with two or more persons qualify as HOVs and travel toll free in all corridors except I-80 ALA-CC and the I-880 northbound approach to the Bay Bridge.

*** Increase HOV occupancy requirement from two persons to three persons in corridors where HOV volumes are forecast to approach 1,600 vehicles per hour by 2020: I-580 and I-680 CC.

It is important to note that while the regional net total revenue is positive, this study suggests that the revenue in some corridors would not be sufficient to cover the incremental costs of constructing and operating HOT lanes. In a regional HOT lane network, it would be necessary to pool revenue from corridors with high net revenue to fund HOT lane construction and operation in corridors with deficits.

Furthermore, the Connected Network forecasts show that net revenues in 2030 (the assumed first year of full operation of that more extensive network) would approximately equal costs if HOV occupancy requirements are not adjusted. Most corridors are estimated to break even or produce slightly positive net revenues. With increased vehicle occupancies in four corridors, this range could increase to $256 million per year to $405 million per year.

Table 1.10-2: Connected HOT Lanes Network, Net Revenue in Year 2030

	Existing HOV Occupancy Requirements*	Increased HOV Occupancy Requirements in Selected Corridors**
Annual Revenue in 2030	$322 to $402 million	$598 to $747 million
Annualized Costs in 2030***	$342 million	$342 million
Annual Net Revenue in 2030	-$20 to $60 million	$256 to $405 million

* Vehicles with two or more persons qualify as HOVs and travel toll free in all corridors except I-80 ALA-CC and the I-880 northbound approach to the Bay Bridge.

** Increase HOV occupancy requirement from two persons to three persons in corridors where HOV volumes are forecast to approach 1,600 vehicles per hour by 2020: I-580 and I-680 CC.

*** Amortized capital cost plus one year of operations and maintenance cost.

Among the important next steps are:

- Review of findings from work to date and identification of key additional information needed
- Development of more detailed HOT lane configurations sufficient to identify appropriate ingress and egress locations, extent of weaving lanes and enforcement areas, locations of toll readers, and significant actions needed (e.g., right of way, structures modifications, etc.). This will enable more reliable usage and revenue forecasting as well as HOT lane costing.
- Consideration of 2050 travel forecasts and corresponding revenue forecasts for HOT lanes to provide a longer term assessment of revenues and costs for the Connected Network.
- Development of travel and revenue forecasts that reflect more closely how users would respond to tolling impacts.

Appendix A

Unit Cost Comparison for HOT Lane Network -- Low, Medium, and High Range Costs Per Lane Mile

(See Spreadsheet)

Appendix B

2015 Existing and Funded Network Construction Costs

(See Spreadsheet)

Appendix C

HOT Network Segments Added 2015 and 2030 Construction Costs

(See Spreadsheet)

Appendix D

2030 Connected Network (2015 Network plus Segments Added Through 2030) Construction Costs

(See Spreadsheet)

Appendix E

Analysis of AM Peak Period HOV Lane Volumes – Existing and Funded Network, 2015 through 2030

(See Spreadsheet)

Appendix F

AM Peak Hour Vehicle Volumes in HOT Lanes and General Purpose Lanes

(See Spreadsheet)